The Effect of Roasted Soybeans in the Diet of Feedlot Steers and Synovex-S Ear Implants on Carcass Characteristics and Estimated Composition[1,2]

T. S. Rumsey*,[3], T. H. Elsasser*, S. Kahl*, and M. B. Solomon†

*Growth Biology Laboratory and †Meat Science Research Laboratory, Livestock and Poultry Sciences Institute, ARS, USDA, Beltsville, MD 20705-2350

ABSTRACT: Beef steer carcasses from three 2 × 2 factorial feeding experiments (Exp. 1, 20 carcasses; Exp. 2 and 3, 19 carcasses each) were evaluated to study the influence of supplementing with roasted soybeans (RSB; 127°C for 10 min) vs soybean meal (SBM) and implanting with the estrogenic growth promoter Synovex-S (SYN, 20 mg estradiol benzoate and 200 mg progesterone) on carcass merit, composition of dissected 9-10-11th rib section, estimated edible carcass composition, and cooking characteristics of strip loin steaks. In all experiments, steers were fed diets consisting of 15% corn silage, 15% orchardgrass silage, and 70% corn-based concentrate. There were no treatment interactions found in this study. Final BW averaged 480.4, 498.5, and 500.7 kg for Exp. 1, 2, and 3, respectively, and hot carcass weights averaged 288.4, 296.4, and 309.1 kg. Across experiments, hot carcass weight was 8.3 kg less ($P < .03$) for RSB steers than for SBM steers. Fat weight ($P < .01$) and percentage of fat ($P < .01$) were less and percentage of bone ($P < .04$) was greater in the 9-10-11th rib section of RSB steers than of SBM steers. Estimated percentage of fat ($P < .02$) was less and percentage of bone ($P < .04$) was greater in edible carcass of RSB steers than in that of SBM steers. Total 9-10-11th rib section weight tended to be less for RSB steers ($P < .08$) than for SBM steers. Carcass merit measurements were not affected ($P > .10$) by supplement, but numerically the percentage of kidney, pelvic, and heart fat was 11% greater for RSB steers than for SBM steers in Exp. 2 and 3. Final BW and carcass weight were 38.7 and 22.6 kg greater ($P < .01$), respectively, for SYN-implanted steers than for steers not implanted. Longissimus muscle area was greater ($P < .01$), percentage of kidney, pelvic, and heart fat ($P < .02$) was less, USDA quality grade tended to be less ($P < .09$), and shear force of strip loin was greater ($P < .01$) for SYN-implanted steers than for steers not implanted. The 9-10-11th rib section and estimated carcass compositions were not different ($P > .10$) between SYN-implanted steers and steers not implanted but reflected a somewhat leaner carcass. The authors conclude from this study that in feedlot steers, either implanted or not implanted, there is no benefit from supplementing with RSB in place of SBM, and that the use of RSB in place of SBM in feedlot diets may reduce the amount of edible carcass.

Key Words: Steers, Feedlots, Soybeans, Estrogens, Progesterone, Carcass Composition

 J. Anim. Sci. 1999. 77:1726–1734

Introduction

Whole and roasted soybeans (**RSB**) are being used, particularly in lactating cow diets, to provide both supplemental protein and energy. Casper and Schingoethe (1989) reported that this feeding practice seems to slightly reduce milk protein production and hypothesized that the reduced milk protein output results from a reduced secretion of ST in soybean-fed cows. This hypothesis is supported by human (Imaki et al., 1985), laboratory animal (Alvarez et al., 1991),

[1]The authors gratefully acknowledge the technical assistance of D. Carbaugh and A. Kozak, the abattoir assistance of R. Zephir, G. Franklin, and J. Piatt, the animal management assistance of T. Currier and P. Graninger, and the assistance of A. Mitchell and N. Faulkner for determining longissimus muscle area and 9-10-11th rib section composition.

[2]Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by USDA and does not imply its approval to the exclusion of other products that may be suitable.

[3]To whom correspondence should be addressed: Building 200, Room 102, BARC-East (phone: (301) 504-8267; fax: (301) 504-5424; E-mail: trumsey@1psi.barc.usda.gov).

Received August 24, 1998.
Accepted February 12, 1999.

pig (Barb et al., 1995), lamb (Estienne et al., 1990), and lactating cow (Reynaert et al., 1975) studies that suggest oils or specific fatty acids reduce ST release.

Rumsey et al. (1996, 1997) have reported that beef steers fed isocalorically a diet supplemented with RSB gained less than when fed a diet supplemented with soybean meal (**SBM**), and these same RSB steers had reduced ST and thyroid-stimulating hormone (**TSH**) responses to a challenge with thyrotropin-releasing hormone + ST-releasing hormone. Furthermore, in the studies by Rumsey et al. (1996, 1997), the estrogenic implant Synovex-S (**SYN**) seemed to remove the negative effects of feeding RSB. Although the biological effects of RSB suggest that RSB may affect carcass merit and composition, reports in the literature on the effects of supplemental RSB on carcass measurements are lacking, particularly under feedlot conditions. However, Alao and Balnave (1984) suggest that different fats or oils may vary in their influence on growth and carcass composition.

This study was conducted to determine whether differences occur in carcass merit, rib and edible carcass composition, and cooking characteristics of steaks from steers fed RSB vs SBM and implanted or not with SYN. The carcasses were from steers limit-fed isocalorically in a previously reported hormone-challenge experiment (Rumsey et al., 1996, 1997) and from steers given ad libitum access to diets in two feedlot experiments (Rumsey et al., 1999).

Materials and Methods

Animal Care. The animal protocols for the research in this report were approved by the Beltsville Agricultural Research Center Institutional Animal Care and Use Committee.

Experiment 1. In an earlier report, Rumsey et al. (1996) described the details of the design and experimental protocol for this experiment. Briefly, 20 growing beef steers were used in a 2 × 2 factorial arrangement of treatments consisting of a 30:70 silage-concentrate diet (18% crude protein) supplemented with either SBM or RSB and either not implanted or implanted with SYN (20 mg estradiol benzoate plus 200 mg progesterone, Fort Dodge Laboratories, Division of American Home Products, Fort Dodge, IA). The SBM diet contained approximately 47% corn and 21% SBM, and the RSB diet contained approximately 43.5% corn, 5% SBM, and 19.5% RSB. Roasted soybeans were prepared commercially by heating to 127°C for 10 min. Dry matter and protein digestibilities were not different between RSB and SBM diets (Rumsey et al., 1999). Steers were individually fed isocalorically at a level to allow for the SBM steers that were not implanted to gain 1.3 kg/d of BW. Steers were fed for 17 wk and then were killed in the Beltsville abattoir by captive bolt stunning followed by exsanguination. Hormone challenge studies were performed at two times during the feeding experiment (Rumsey et al., 1996), and initially implanted steers were reimplanted at 84 d. Body weights at slaughter averaged 477, 455, 497, and 492 kg for the SBM-SYN, RSB-SYN, SBM+SYN, and RSB+SYN treatments, respectively, and daily gains during the growth periods averaged 1.35, 1.21, 1.47, and 1.38 kg/d.

All steers were processed on the slaughter floor using standard slaughter procedures by trained personnel, and all carcasses were weighed, longitudinally split, and then chilled for 48 h. The right half of each chilled carcass was 1) scored for kidney, pelvic, and heart (**KPH**) fat percentage, marbling, lean color, lean texture, lean firmness, heat ring, fat color, USDA quality grade, and yield grade; 2) measured for fat over the longissimus muscle and longissimus muscle area; and 3) cut to remove the 9-10-11th standing rib section (Hankins and Howe, 1946). All scoring, measuring, and cutting of the chilled carcasses were performed by a professional meat scientist. After the 9-10-11th rib sections were removed from the chilled carcasses and chilled for an additional 48 h, each section was weighed and dissected by trained personnel to separate lean, fat, and bone. The dissected components were weighed, and the longissimus muscle was cross-sectioned into 2.5-cm strip loin steaks and frozen.

In triplicate, steaks were thawed to 5°C, weighed, cooked on a Farberware Open Hearth grill to an internal temperature of 71°C, weighed again to determine loss during cooking, and triplicate cores removed for shear force determination.

Experiments 2 and 3. These experiments were replicate feedlot experiments conducted during the same months in two consecutive years using steers and heifers from the Beltsville nutrition research herd. Details of the design and protocol of these experiments are described by Rumsey et al. (1999). In brief, each experiment consisted of 20 steers and 20 heifers assigned on the basis of BW to eight group pens (five steers or heifers per pen) arranged in a 2 × 2 factorial arrangement of treatments. Treatments were the same as for Exp. 1. All animals were given ad libitum access to the diets to achieve approximately 10% feed refusal each day. The initially implanted animals were reimplanted at 80 d. For this study, only the steers from each of these experiments (19/experiment) were slaughtered in the Beltsville abattoir after 160 d on feed. In Exp. 2, 1 of the 20 steers was removed at the midpoint of the experiment because of an acute respiratory infection. In Exp. 3, 1 of the 20 steers died near the end of the experiment from a kidney infection. Final steer BW averaged 477, 476, 533, and 513 kg for the SBM-SYN, RSB-SYN, SBM+SYN, and RSB+SYN treatments, respectively, and daily gains averaged 1.37, 1.41, 1.63, and 1.56 kg/d.

All slaughter, scoring, dissection procedures, and measurements were the same as those described for Exp. 1.

Statistical Procedures. Statistical procedures used in this study are described in SAS (1989). For Exp. 1, all individual carcass data were analyzed as a 2 × 2 factorial with GLM procedures. Supplement and implant treatments and their interaction were in the model, and mature BW of the dam (BW at weaning) was used as a covariate. Additionally, the initial model included slaughter group as a factor, which was dropped from the model because of lack of significance ($P > .10$). For Exp. 2 and 3, individual carcass data were evaluated in a combined analysis using the same procedures as for Exp. 1 with trial added to the initial and final models as a replicate factor. A third analysis combined the data from all experiments and used the same procedures as in the analysis for Exp. 2 and 3. Data are reported as least squares means. Treatments were considered to be different if $P \leq .05$ and to show a trend if $P \leq .10$.

Results

Experiment 1. Results from this experiment represent steers that were individually fed isocalorically on the basis of metabolizable energy per unit of metabolic body weight to allow the SBM steers that were not implanted with SYN to gain 1.3 kg/d live weight. There were no supplement × SYN interactions ($P > .10$). A summary of final BW and carcass weight, dressing percentage, and carcass merit data is shown in Table 1. Final BW was numerically less for RSB steers than for SBM steers, but not significantly so ($P > .10$). Across treatments, average initial BW was similar (data not shown). However, both carcass weight ($P < .04$) and dressing percentage ($P < .03$) were less for RSB steers than for SBM steers.

Although not significant, KPH fat score and fat over the longissimus muscle were numerically less (22%) for RSB steers than for SBM steers. Marbling score was less (17%, $P < .02$) for RSB steers than for SBM steers. Longissimus muscle area, lean color, texture and firmness, and fat color were not different ($P > .10$) between RSB and SBM steers. Quality grade and yield grade were not different ($P > .10$) between RSB and SBM steers but numerically reflected the lower fat content of carcasses from RSB steers compared with SBM steers. Heat ring was detected in two steers that were both fed the RSB diet.

Both final BW ($P < .02$) and carcass weight ($P < .03$) were greater for SYN-implanted steers than for steers not implanted. Dressing percentage was greater ($P < .03$) for SYN-implanted steers than for steers not implanted. Kidney, pelvic, and heart fat score, fat over

Table 1. Influence of supplemental soybean meal (SBM) vs roasted soybeans (RSB) and Synovex-S ear implant (SYN) on carcass merit of beef steers, Experiment 1

	Supplement		SYN			*P* <	
Item	SBM	RSB	–	+	SEM[a]	RSB	SYN
n	10	10	10	10			
Final body weight, kg	488.6	472.3	466.4	494.5	7.01	NS[j]	.02
Carcass weight, kg	296.0	280.7	277.3	299.3	8.74	.04	.01
Dressing percentage	60.5	59.4	59.4	60.5	.32	.03	.03
Kidney, pelvic, and heart fat, %	2.02	1.58	1.95	1.65	.20	NS	NS
Fat over longissimus muscle, cm	.85	.66	.80	.71	.09	NS	NS
Longissimus muscle area, cm^2	77.1	75.1	72.3	79.9	1.93	NS	.01
Marbling[b]	4.17	3.46	3.99	3.64	.19	.02	NS
Lean color[c]	5.0	4.9	4.9	5.0	.21	NS	NS
Lean texture[d]	5.1	4.8	5.0	4.9	.15	NS	NS
Lean firmness[e]	4.5	4.9	4.7	4.7	.33	NS	NS
Heat ring[f]	0	.3	.1	.2	ND[k]	ND	ND
Fat color[g]	4.8	4.6	4.6	4.8	.16	NS	NS
USDA quality grade[h]	10.4	9.8	10.2	10.0	.40	NS	NS
Yield grade[i]	2.21	2.09	2.28	2.02	.16	NS	NS

[a]SEM = common standard error of the mean from analysis of variance, n = 10.
[b]Scores: 3.00 = small$^{.00}$ to 5.00 = moderate$^{.00}$.
[c]Scores: 1 = very dark red to 8 = very light cherry red.
[d]Scores: 1 = very coarse to 8 = very fine.
[e]Scores: 1 = very soft to 8 = very firm.
[f]Scores: 0 = none to 4 = extreme.
[g]Scores: 1 = yellow to 5 = white.
[h]Scores: 8 = Select, 9 = High Select, 10 = Low Choice, 11 = Choice.
[i]Scores: 1 = least fat to 5 = most fat.
[j]NS = not significant, $P > .10$.
[k]ND = not determinable. All carcasses scored 0 for heat ring except three; one carcass from the RSB × –SYN treatment and two carcasses from the RSB × +SYN treatment scored 1.

Table 2. Influence of supplemental soybean meal (SBM) vs roasted soybeans (RSB) and Synovex-S ear implant (SYN) on rib and edible carcass composition of beef steers, Experiment 1

	Supplement		SYN			P <	
Item	SBM	RSB	–	+	SEM[a]	RSB	SYN
n	10	10	10	10			
9-10-11th Rib dissection							
Total rib weight, g	4,171.5	3,858.4	3,914.5	4,115.5	166.2	NS[b]	NS
Lean weight, g	2,051.7	1,956.3	1,946.1	2,061.9	110.2	NS	NS
Fat weight, g	1,261.8	906.3	1,122.6	1,045.5	77.8	.01	NS
Bone weight, g	856.8	869.6	832.3	894.0	33.0	NS	NS
Cutting loss, %	.3	.4	.4	.3	.1	NS	NS
Lean, %	48.9	51.0	49.6	50.3	1.7	NS	NS
Fat, %	30.0	26.1	28.6	27.5	1.5	.10	NS
Bone, %	20.8	22.6	21.5	21.8	.7	.10	NS
Edible carcass composition[c]							
Lean, %	55.3	56.8	55.7	56.3	1.4	NS	NS
Fat, %	27.6	24.4	26.4	25.6	1.2	.10	NS
Bone, %	17.3	18.4	17.8	18.0	.4	.10	NS

[a]SEM = common standard error of the mean from analysis of variance, n = 10.
[b]NS = not significant, $P > .10$.
[c]Hankins and Howe (1946).

the longissimus muscle, and marbling were numerically less (15, 11, and 9%, respectively), but not significantly so ($P > .10$), for SYN-implanted steers than for steers not implanted. Longissimus muscle area was greater ($P < .01$) for SYN-implanted steers than for steers not implanted. Lean color, texture, and firmness and fat color were not different ($P > .10$) between SYN-implanted steers and steers not implanted. Quality grade and yield grade were not different ($P > .10$) between SYN-implanted steers and steers not implanted but numerically reflected the lower fat content in the carcasses from the SYN steers. Heat ring was detected in one steer each for the SYN-implanted and unimplanted treatments.

A summary of the 9-10-11th standing rib section dissection and estimated edible carcass composition is shown in Table 2. There were no supplement × implant treatment interactions ($P > .10$). Total rib, lean, and bone weights were not different ($P > .10$) between RSB and SBM steers, but, numerically, total rib and lean weights were less (7.5 and 5%, respectively) for RSB steers than for SBM steers, consistent with lower carcass weight for RSB steers. Fat weight was less (28%, $P < .01$) for RSB steers than for SBM steers.

A summary of shear force and cooking loss is shown in Table 3. No differences ($P > .10$) were obtained for these measurements between either the supplement or implant treatments.

Experiments 2 and 3. These trials represent steers that were group-fed for ad libitum intake. As in Exp. 1, there were no interactions ($P > .10$) among treatment effects. A summary of BW and carcass weight, dressing percentage, and carcass merit data is

Table 3. Influence of supplemental soybean meal (SBM) vs roasted soybeans (RSB) and Synovex-S ear implant (SYN) on Warner-Bratzler shear and cooking loss of loin steaks of beef steers, Experiments 1, 2, and 3

	Supplement		SYN		Experiment			P <		
Item[a]	SBM	RSB	–	+	2	3	SEM[b]	RSB	SYN	Trial
Experiment 1										
n	10	10	10	10						
Shear, kg	3.68	3.89	3.69	3.87			.19	NS[c]	NS	
Cooking loss, %	37.4	39.0	38.3	38.2			2.7	NS	NS	
Experiments 2 and 3										
n	18	20	19	19	19	19				
Shear, kg	5.39	5.35	4.70	6.05	5.76	4.98	.34	NS	.01	NS
Cooking loss, %	26.6	27.2	26.1	27.7	27.0	26.9	.9	NS	NS	NS

[a]Strip loin steaks, 2.5 cm, were cooked on Farberware Open Hearth grills to an internal temperature of 71°C, then cores were removed for shearing on the Food Technology Corp. texture measurement system for obtaining shear force values.
[b]SEM = common standard error of the mean from analysis of variance, n = 10 for Trial 1 and 19 for the combined Exp. 2 and 3.
[c]NS = not significant, $P > .10$.

shown in Table 4. Between experiments, final BW and carcass weight were similar (*P* > .10). Most other carcass merit indicators were similar between experiments, except that dressing percentage was greater (4%, *P* < .001), kidney, pelvic, and heart fat score was lower (30%, *P* < .001), and longissimus muscle area tended to be greater (6%, *P* < .06) for steers in Exp. 2 than for steers in Exp. 1.

There were no differences (*P* < .10) in BW and carcass weight, dressing percentage, and carcass merit data between the RSB- and SBM-fed steers for these experiments. However, final BW, carcass weight, fat over the longissimus muscle, quality grade, and yield grade reflected similar numerical differences as in Exp. 1. Conversely, KPH fat score was numerically greater in RSB-fed steers than in SBM-fed steers.

Final BW and carcass weight were greater (*P* < .01) and longissimus muscle area tended to be greater (*P* < .10) in SYN-implanted steers than in steers not implanted. Implanted steers had less (*P* < .02) KPH fat and tended to have a lower (*P* < .07) dressing percentage than steers not implanted. Other carcass merit measures were not different (*P* > .10) between the implanted and unimplanted treatments, except lean texture score tended to be greater (*P* < .10) for the implanted steers and quality grade tended to be lower (*P* < .07) for implanted steers than for steers not implanted. Numerically, yield grade values reflected the same directional differences as seen in Exp. 1. Heat ring was detected in the carcass of one steer from each of the four treatment groups.

A summary of the 9-10-11th standing rib section dissection and estimated edible carcass composition for Exp. 2 and 3 is shown in Table 5. There were no supplement × implant treatment interactions (*P* > .10). Although final BW and carcass weight were similar between Exp. 2 and 3, total rib and lean weights were greater (*P* < .01) in Exp. 3 than in Exp. 2. Also, the percentages of lean in the rib section and edible carcass were greater (*P* < .02) and the percentages of bone in the rib section and edible carcass were less (*P* < .02) in Exp. 3 than in Exp. 2. Other compositional measures were not different (*P* > .10) between Exp. 2 and 3.

Fat weight of the dissected 9-10-11th rib section (*P* < .08) and fat percentage of both the rib section (*P* < .10) and edible carcass (*P* < .10) tended to be less for RSB steers than for SBM steers, consistent with the effect on fat content in Exp. 1. Other compositional measures were not different (*P* > .10) between the RSB and SBM treatments.

Lean weight in the dissected 9-10-11th rib section tended to be greater (*P* < .08) for the SYN-implanted steers than for the steers not implanted. All other

Table 4. Influence of supplemental soybean meal (SBM) vs roasted soybeans (RSB) and Synovex-S ear implant (SYN) on carcass merit of beef steers, Experiments 2 and 3

	Supplement		SYN		Experiment			*P* <		
Item	SBM	RSB	–	+	2	3	SEM[a]	RSB	SYN	Trial
n	18	20	19	19	19	19				
Final body weight, kg	502.7	491.4	475.0	519.2	498.5	500.7	7.07	NS[j]	.01	NS
Carcass weight, kg	304.2	298.4	289.4	313.1	296.4	309.1	3.88	NS	.01	NS
Dressing percentage	60.5	60.8	61.0	60.3	59.5	61.8	.78	NS	.07	.01
Kidney, pelvic, and heart fat, %	1.56	1.74	1.87	1.43	1.92	1.34	.11	NS	.02	.01
Fat over longissimus muscle, cm	1.44	1.36	1.43	1.38	1.43	1.37	.10	NS	NS	NS
Longissimus muscle area, cm^2	70.5	69.7	68.4	71.8	68.1	72.1	1.39	NS	.10	.06
Marbling[b]	3.13	3.14	3.21	3.06	3.45	2.83	.31	NS	NS	NS
Lean color[c]	5.4	5.4	5.3	5.5	5.3	5.5	.17	NS	NS	NS
Lean texture[d]	6.1	6.3	5.9	6.5	6.1	6.4	.26	NS	.10	NS
Lean firmness[e]	5.8	5.3	5.4	5.7	5.5	5.5	.32	NS	NS	NS
Heat ring[f]	.1	.3	.3	.2	.5	0	ND[k]	ND	ND	ND
Fat color[g]	4.7	4.7	4.7	4.6	4.5	4.8	.13	NS	NS	NS
USDA quality grade[h]	9.1	8.8	9.5	8.5	9.2	8.7	.39	NS	.07	NS
Yield grade[i]	3.28	3.22	3.31	3.19	3.38	3.12	.14	NS	NS	NS

[a]SEM = common standard error of the mean from analysis of variance, n = 19.
[b]Scores: 3.00 = small$^{.00}$ to 5.00 = moderate$^{.00}$.
[c]Scores: 1 = very dark red to 8 = very light cherry red.
[d]Scores: 1 = very coarse to 8 = very fine.
[e]Scores: 1 = very soft to 8 = very firm.
[f]Scores: 0 = none to 4 = extreme.
[g]Scores: 1 = yellow to 5 = white.
[h]Scores: 8 = Select, 9 = High Select, 10 = Low Choice, 11 = Choice.
[i]Scores: 1 = least fat to 5 = most fat.
[j]NS = not significant, *P* > .10.
[k]ND = not determinable. All carcasses scored 0 for heat ring except four in trial 2; one carcass from the SBM × −SYN treatment scored 1, one carcass from the SBM × +SYN treatment scored 1, one carcass from the RSB × −SYN treatment scored 4, and one carcass from the RSB × +SYN treatment scored 3.

Table 5. Influence of supplemental soybean meal (SBM) vs roasted soybeans (RSB) and Synovex-S ear implant (SYN) on rib and edible carcass cmposition of beef steers, Experiments 2 and 3

	Supplement		SYN		Experiment			P <		
Item	SBM	RSB	–	+	2	3	SEM[a]	RSB	SYN	Trial
n	18	20	19	19	19	19				
9-10-11th Rib dissection										
Total rib weight, g	4,592.9	4,444.0	4,414.7	4,622.2	4,248.6	4,780.5	118.7	NS[b]	NS	.01
Lean weight, g	2,070.0	2,062.5	1,983.6	2,149.0	1,882.4	2,249.7	65.5	NS	.08	.01
Fat weight, g	1,652.9	1,496.6	1,577.9	1,571.6	1,498.1	1,643.2	61.2	.08	NS	NS
Bone weight, g	829.5	856.3	820.5	865.3	850.1	872.2	28.5	NS	NS	NS
Cutting loss, %	.4	.3	.3	.4	.4	.3	.1	NS	NS	NS
Lean, %	45.0	46.3	44.8	46.6	44.3	47.1	.9	NS	NS	.02
Fat, %	36.0	33.8	35.8	33.9	35.3	34.3	.9	.10	NS	NS
Bone, %	18.6	19.6	19.0	19.1	20.0	18.3	.5	NS	NS	.02
Edible carcass composition[c]										
Lean, %	52.1	53.1	51.9	53.3	51.5	53.8	.7	NS	NS	.02
Fat, %	32.3	30.6	32.2	30.6	31.8	31.0	.7	.10	NS	NS
Bone, %	16.1	16.7	16.4	16.4	16.9	15.9	.3	NS	NS	.02

[a]SEM = common standard error of the mean from analysis of variance, n = 19.
[b]NS = not significant, *P* > .10.
[c]Hankins and Howe (1946).

compositional measures were not different (*P* > .10) between implant treatments, except total rib weight was numerically larger for the implanted steers than for the steers not implanted, consistent with the final BW and carcass weight for Exp. 2 and 3 and with Exp. 1.

A summary of shear force and cooking loss for Exp. 2 and 3 is shown in Table 3. Shear force was greater (29%, *P* < .01) for SYN-implanted steers than for steers not implanted, but it was not different (*P* > .10) between supplement treatments or experiments. No differences (*P* > .10) were obtained for cooking loss between either the supplement or implant treatments or between experiments.

Combined Summary, Experiments 1, 2, and 3. A summary of the statistically significant factors from the combined analysis of all experiments is shown in Table 6. Final BW tended to be less (*P* < .08) for RSB

Table 6. Influence of supplemental soybean meal (SBM) vs roasted soybeans (RSB) and Synovex-S ear implant (SYN) on carcass merit, rib and edible carcass composition, and tenderness of beef steers, combined summary of least squares means of Experiments 1, 2, and 3

	Supplement		SYN			P <	
Item	SBM	RSB	–	+	SEM[a]	RSB	SYN
n	28	30	29	29			
Carcass merit							
Final body weight, kg	499.8	487.3	474.2	512.9	5.18	.08	.01
Carcass weight, kg	302.3	294.0	286.8	309.4	2.88	.03	.01
Kidney, pelvic, and heart fat, %	1.71	1.66	1.86	1.50	.11	NS[d]	.02
Longissimus muscle area, cm^2	72.6	71.6	69.8	74.5	1.14	NS	.01
USDA quality grade[b]	9.5	9.2	9.7	9.0	.31	NS	.09
9-10-11th Rib dissection							
Total rib weight, g	4,431.5	4,197.1	4,219.7	4,408.9	90.5	.08	NS
Fat weight, g	1,518.2	1,306.4	1,429.4	1,395.2	48.6	.01	NS
Fat, %	34.0	31.2	33.4	31.8	.75	.01	NS
Bone, %	19.3	20.6	19.8	20.1	.40	.04	NS
Edible carcass composition[c]							
Fat, %	30.7	28.5	30.3	29.0	.60	.02	NS
Bone, %	16.5	17.2	16.8	17.0	.23	.04	NS
Shear force of strip loin, kg	4.82	4.86	4.37	5.32	.23	NS	.01

[a]SEM = common standard error of the mean from analysis of variance, n = 29.
[b]Scores: 8 = Select, 9 = High Select, 10 = Low Choice, 11 = Choice.
[c]Hankins and Howe (1946).
[d]NS = not significant, *P* > .10.

steers than for SBM steers, and carcass weight was less ($P < .03$) for RSB than for SBM steers. Total 9-10-11th standing rib section weight tended to be less ($P < .08$) for RSB steers than for SBM steers, and fat weight and the percentage of rib fat were less ($P < .01$) for RSB than for SBM steers. The percentage of rib bone was greater ($P < .04$) for RSB than for SBM steers. Estimated percentage of fat in the edible carcass was less ($P < .02$) and bone in the edible carcass was greater ($P < .04$) for RSB steers than for SBM steers.

Final BW and carcass weight and longissimus muscle area were all greater ($P < .01$) for SYN-implanted steers than for steers not implanted. In addition, KPH fat score was less ($P < .02$) and quality grade tended to be less ($P < .09$) for implanted steers than for steers not implanted. The dissected 9-10-11th rib section measurements and estimated edible carcass composition were not affected ($P > .10$) by implant treatment; however, shear force was greater ($P < .01$) for SYN-implanted steers than for steers not implanted.

Discussion

Numerous studies with varying results have been reported on the use of energy-dense fats and oils in animal diets to improve performance and influence carcass and(or) fat composition. Alao and Balnave (1984) have pointed out that different fats or oils may vary in their influence on growth and carcass composition. There are additional limitations of feeding fats to ruminants with regard to negative effects on ruminal fermentation that may influence diet digestibility and nutrient availability and the ruminal effect on hydrogenation that requires protecting added dietary fats in ruminant diets if the end result is to be a change in fat composition. Thus, the specific results expected from feeding fats or oils in animal diets is both source- and species-specific.

Feeding oil to ruminants in the form of whole oil seeds is of particular interest to the dairy producer as a means of increasing the energy density of the diet during lactation and providing protein at the same time. One specific problem resulting from this feeding practice has been a reduction in the output of milk protein (Casper and Schingoethe, 1989), and these authors hypothesized an effect on the hypothalamic-pituitary axis that results in a reduction in ST output. Additionally, thyroid status in ruminants has been shown to be affected by specific fatty acids and dietary fats (Norton et al., 1987, 1988; Kahl et al., 1991; Su and Jones, 1993). Most recently, for the steers in Exp. 1 of the current study, Rumsey et al. (1996, 1997) reported that supplementing with RSB, when compared isocalorically with controls, reduced weight gains, pituitary release of ST and TSH following a releasing hormone challenge, reduced thyroid hormone baseline plasma concentrations, and tended to reduce pituitary 5′-deiodinase activity.

The biological effects of feeding RSB to steers suggest that differences may be expected in carcass composition. In the current study, the carcasses of steers from Exp. 1 reflected the reduced growth of the RSB-fed steers consistent with a reduced ST release. The reduced growth is consistent with results of Erickson and Barton (1987) for lambs and Putnam et al. (1969) for steers showing reduced growth when whole soybeans and soy oil, respectively, were fed, with digestibilities being equal. Digestibilities were also similar between the SBM and RSB diets in the current study (Rumsey et al., 1999). Although thyroid status was depressed in these steers, there seemed to be a reduction in the fat content of the carcass. This is inconsistent with the fact that reduced thyroid status results in reduced metabolic rate, and potentially an increase in fat deposition under conditions of equal energy intake. For example, Garrett et al. (1976) obtained greater fat deposition when encapsulated vegetable oils were fed to steers. However, in the study of Putnam et al. (1969), soybean oil tended to reduce carcass grade, dressing percentage, and marbling score. Possibly the effect of RSB on thyroid status in the present study was not enough to influence nutrient partitioning or whole-body fat deposition.

Under conditions that more closely resemble those of the feedlot (Exp. 2 and 3), this study would indicate that giving steers ad libitum access to feed removes any apparent negative influence on carcass growth or quality measures, but, consistent with limited feeding (Exp. 1), there was a trend for carcass fat deposition to be reduced. Concurrently, percentage of KPH fat was numerically greater in RSB-fed steers than in SBM-fed steers in Exp. 2 and 3. This suggests that perinephric noncarcass fat may be the site of greater fat deposition under ad libitum levels of intake when RSB is fed. Thus, the use of roasted soybeans in feedlot diets, on a whole-animal basis, does not seem to improve performance and may have a negative effect on carcass quality factors.

The hypothalamic-pituitary axis plays a major regulatory role in growth and the partitioning of nutrients for specific tissue growth. Estrogens have been shown to increase the release of TSH but not of ST from the pituitary (Rumsey et al., 1996, 1997). Estrogens have been shown to elevate blood and tissue IGF-I (Rumsey and Elsasser, 1989). These TSH and IGF-I changes are consistent with increased growth rate and protein deposition (Rumsey et al., 1981; Rumsey, 1982) and increased rate of metabolism (Rumsey et al., 1980; Rumsey and Hammond, 1990) in beef steers treated with estrogenic growth promoters.

Several studies have been reported from the 1950s to 1970s on the influence of the estrogenic-like growth promoter diethylstilbestrol, and, since the 1970s, on estradiol-formulated ear implants regarding their effects on carcass composition and growth. Typical effects of these materials have been to increase carcass weight and muscle deposition (i.e., increase longissimus muscle area; Rumsey et al., 1992b) and a trend toward changing carcass merit and quality scores to reflect a leaner carcass (Wilson et al., 1963). Consistent with the literature, typical responses to estrogenic growth promoters toward a leaner carcass were found in the current study.

Tenderness, as measured by shear force, was less desirable in the SYN-implanted steers than in the steers not implanted. Gerken et al. (1995) stated that a limited amount of data is available concerning the effects of implants on beef tenderness. They found that SYN implants decreased tenderness of top sirloin steaks, as measured by sensory panel tenderness, but shear force was not significantly affected by SYN. Likewise, Apple et al. (1991) reported that SYN tended to lower sensory panel tenderness scores but did not significantly lower shear force. In agreement with the current study, Simone et al. (1958) reported that diethylstilbestrol increased shear force. The possible negative effect of estrogens on beef tenderness is an important industry concern and needs further study (Gerken et al., 1995).

There is a lack of reports in the literature on the combined effects of an estrogenic growth promoter that is known to influence the hypothalamic-pituitary axis (Rumsey et al., 1996) and dietary oil or supplemental soybeans that has been shown to reduce ST and TSH release from the pituitary (Rumsey et al., 1996, 1997). Putnam et al. (1969) reported the results of one experiment in which both diethylstibestrol and supplemental soybean oil were used in diets of beef steers. There were no treatment interactions reported for that experiment, as was also the case in the current study. In a study in which unimplanted and Synovex-implanted steers were fed propylthiouracil to suppress peripheral triiodothyronine production, depressed thyroid status tended to increase BW gain in the unimplanted and the implanted steers but increased protein gain in only the implanted steers and increased fat gain in only the unimplanted steers (Rumsey et al., 1992a). Because Rumsey et al. (1996) found the negative effect of RSB on BW gain to be alleviated when steers were implanted with SYN, the increased release of TSH in SYN-implanted steers compared with unimplanted steers (Rumsey et al., 1997) may neutralize a negative effect of RSB on TSH release. However, these types of interactions were not seen in measurements in the current study, suggesting once more that the apparent depression in thyroid status was not great enough to cause a significant interactive effect (supplement × SYN) on carcass characteristics in this study.

Implications

Including whole oil seed in ruminant diets may be a practical means of increasing the energy density of the diet and adding supplemental protein. However, feeding roasted soybeans to growing steers may reduce the output of somatotropin (growth hormone) and thyroid-stimulating hormone by the pituitary and reduce growth per unit of feed input. The current study determined whether the feeding of roasted soybeans affected estimated carcass composition and merit in feedlot steers either implanted with Synovex-S or not implanted, particularly as related to feedlot conditions. In the implanted and the unimplanted steers, carcass weight and the amount of carcass fat deposited was less in steers fed roasted soybeans than in steers fed soybean meal, and carcass merit measurements were not affected. Thus, including roasted soybeans in diets of feedlot cattle does not seem beneficial, and it may reduce the amount of edible carcass.

Literature Cited

Alao, S. J., and D. Balnave. 1984. Growth and carcass composition of broilers fed sunflower oil and olive oil. Br. Poult. Sci. 25: 209–219.

Alvarez, C. V., F. Mallo, B. Burguera, L. Caicedo, C. Dieguez, and F. F. Casanueva. 1991. Evidence of a direct pituitary inhibition by free fatty acids of in vivo growth hormone responses to growth hormone-releasing hormone in the rat. Neuroendocrinology 53: 185–189.

Apple, J. K., M. E. Dikeman, D. D. Simms, and G. Kuhl. 1991. Effects of synthetic hormone implants, singularly or in combinations, on performance, carcass traits, and longissimus muscle palatability of Holstein steers. J. Anim. Sci. 69:4437–4448.

Barb, C. R., R. R. Kraeling, and G. B. Rampacek. 1995. Glucose and free fatty acid modulation of growth hormone and luteinizing hormone secretion by cultured porcine pituitary cells. J. Anim. Sci. 73:1416–1423.

Casper, D. P., and D. J. Schingoethe. 1989. Model to describe and alleviate milk protein depression in early lactation dairy cows fed a high fat diet. J. Dairy Sci. 72:3327–3335.

Erickson P. S., and B. A. Barton. 1987. Whole soybeans for market lambs. J. Anim. Sci. 64:1249–1254.

Estienne, M. J., K. K. Schillo, S. M. Hileman, M. A. Green, S. H. Hayes, and J. A. Boling. 1990. Effects of free fatty acids on luteinizing hormone and growth hormone secretion in ovariectomized lambs. Endocrinology 126:1934–1940.

Garrett, W. N., Y. T. Yang, W. L. Dunkley, and L. M. Smith. 1976. Energy utilization, feedlot performance and fatty acid composition of beef steers fed protein encapsulated tallow or vegetable oils. J. Anim. Sci. 42:1522–1533.

Gerken, C. L., J. D. Tatum, J. B. Morgan, and G. C. Smith. 1995. Use of genetically identical (clone) steers to determine the effects of estrogenic and androgenic implants on beef quality and palatability characteristics. J. Anim. Sci. 73:3317–3324.

Hankins, O. G., and P. E. Howe. 1946. Estimation of the composition of beef carcasses and cuts. Tech. Bull. No. 926. USDA, Washington, DC.

Imaki, T., T. Shibasaki, K. Shizume, A. Masuda, M. Hotta, Y. Kiyosawa, K. Jibiki, H. Demura, T. Tsushima, and N. Ling. 1985. The effect of free fatty acids on growth hormone (GH)-releasing hormone-mediated GH secretion in man. J. Clin. Endocrinol. Metab. 60:290–293.

Kahl, S., D. S. Lough, T. S. Rumsey, T. H. Elsasser, M. B. Solomon, and L. L. Slyter. 1991. Dietary palm oil supplementation increases hepatic 5′-deiodinase activity in growing ram and ewe lambs. J. Anim. Sci. 69(Suppl. 1):167 (Abstr.).

Norton, S. A., T. S. Rumsey, and T. H. Elsasser. 1987. In vitro studies of the influence of lauric and stearic acids on 5′-monodeiodination of thyroxine (T_4) in bovine liver homogenate. J. Anim. Sci. 65(Suppl. 1):272–273 (Abstr.).

Norton, S. A., T. S. Rumsey, and M. T. Pello. 1988. In vitro effects of caprylic acid infusion on bovine thyroxine metabolism. J. Anim. Sci. 66 (Suppl. 1):264 (Abstr.).

Putnam, P. A., R. R. Oltjen, and J. Bond. 1969. Effect of soybean oil, urea, roughage and a progestigin on the utilization of corn based finishing rations by beef cattle. J. Anim. Sci. 28:256–262.

Reynaert, R., M. DePaepe, S. Marcus, and G. Peeters. 1975. Influence of serum free fatty acid levels on growth hormone secretion in lactating cows. J. Endocrinol. 66:213–224.

Rumsey, T. S. 1982. Effect of Synovex-S implants and kiln dust on tissue gain by feedlot beef steers. J. Anim. Sci. 54:1030–1039.

Rumsey, T. S., and T. H. Elsasser. 1989. Insulin-like growth factor-1 (IGF-1) in beef steers treated with Synovex-S (SI) and propylthiouracil (PTU): Relationship with tissue deposition. J. Anim. Sci. 67(Suppl. 1):218 (Abstr.).

Rumsey, T. S., T. H. Elsasser, and S. Kahl. 1996. Roasted soybeans and an estrogenic growth promoter affect growth hormone status and performance of beef steers. J. Nutr. 126:2880–2887.

Rumsey, T. S., T. H. Elsasser, and S. Kahl. 1997. Roasted soybeans and an estrogenic growth promoter affect the thyroid status of beef steers. J. Nutr. 127:352–358.

Rumsey, T. S., T. H. Elsasser, S. Kahl, and M. B. Solomon. 1999. Performance and digestibilities for beef cattle fed diets supplemented with either soybean meal or roasted soybeans and implanted with Synovex®. J. Anim. Sci. 77:1631–1637.

Rumsey, T. S., T. H. Elsasser, S. A. Norton, A. S. Kozak, and S. Kahl. 1992a. Influence of thyroid status regulation and Synovex-S implants on growth performance and tissue gain in beef steers. Domest. Anim. Endocrinol. 9:173–180.

Rumsey, T. S., and A. C. Hammond. 1990. Effects of intake level on metabolic response to estrogenic growth promoters in beef steers. J. Anim. Sci. 68:4310–4318.

Rumsey, T. S., A. C. Hammond, and J. P. McMurtry. 1992b. Response to reimplanting beef steers with estradiol benzoate and progesterone: Performance, implant absorption pattern, and thyroxine status. J. Anim. Sci. 70:995–1001.

Rumsey, T. S., H. F. Tyrrell, D. A. Dinius, P. W. Moe, and H. R. Cross. 1981. Effect of diethylstilbestrol on tissue gain and carcass merit of feedlot beef steers. J. Anim. Sci. 53:589–600.

Rumsey, T. S., H. F. Tyrrell, and P. W. Moe. 1980. Effect of diethylstilbestrol and Synovex-S on fasting metabolism measurements of beef steers. J. Anim. Sci. 50:160–166.

SAS. 1989. SAS/STAT® User's Guide (Version 6, 4th Ed.). SAS Inst. Inc., Cary, NC.

Simone, M., M. T. Clegg, and F. Carroll. 1958. Effect of methods of stilbestrol administration on quality factors of beef. J. Anim. Sci. 17:834–840.

Su, W., and P.J.H. Jones. 1993. Dietary fatty acid composition influences energy accretion in rats. J. Nutr. 123:2109–2114.

Wilson, L. L., C. A. Dinkel, D. E. Ray, and J. A. Minyard. 1963. Beef carcass composition as influenced by diethylstilbestrol. J. Anim. Sci. 22:699–701.