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Ascophyllum Nodosum Supplementation Strategies That Improve Overall Carcass Merit of Implanted English Crossbred Cattle

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ABSTRACT : English crossbred steers (n = 32) and heifers (n = 32) were fed a corn- based finishing diet and supplemented with 2% *Ascophyllum nodosum* on a DM basis to for various feeding stages of the 119 d feeding period determine the supplementation strategy that maximized intramuscular fat deposition as determined by quality grade. All cattle were implanted with Ralgro® on d 36 of the trial and re-implanted with Revalor-S® or Revalor-H® on d 92. Cattle were blocked by sex and divided into one control and three treatment groups receiving *Ascophyllum nodosum*. Treatment 1 (trt 1) received *Ascophyllum nodosum* from d 36 to 50 of the feeding period, trt 2 received *Ascophyllum nodosum* for the last 14 d of the feeding period, and trt 3 which received *Ascophyllum nodosum* for both d 36-50 and the last 14 d of the feeding period. Cattle were weighted initially (385±4.53 kg) and every 28 d following until they reach an average BW of 554±7.46 kg. No effect for *Ascophyllum nodosum* supplementation was found on measured performance characteristics. All treatment groups supplemented with *Ascophyllum nodosum* had higher actual marbling scores ($p<0.05$) than controls. Trt 1 was found to have a highest marbling score (572.5; $p<0.05$), whereas the control group having the lowest marbling score (473.8). Trt 1 had a higher quality grade (5.25; $p<0.05$) than the control (3.94) group, but did not differ from trt 2 (4.56; $p = 0.105$) and trt 3 (4.75; $p = 0.236$) where high Select = 4, and low Choice = 5. Trt 2 did not differ from trt 3 ($p = 0.655$), or the control group ($p = 0.140$) for quality grade. However, trt 3 did tend to differ ($p = 0.057$) from the control group for quality grade. Control group animals graded 25% Choice, 62.5% Select; trt 1 graded 75% Choice, 18.8% Select; trt 2 graded 62.5% Choice, 25% Select and trt 3 graded 56.3% Choice and 31.2% Select. Overall, treatment groups had a 39.6% increase in Choice quality grade and a 37.5% decrease in Select quality grade when compared to the control animals. (**Key Words :** *Ascophyllum nodosum*, Finishing Cattle, Intramuscular Fat)

INTRODUCTION

Marbling is a contributing factor in beef palatability; a determining factor in identifying "desirable" steaks and one of the main factors in determining USDA quality grade, which makes it a critical factor in beef marketing (Tatum et al., 1982; Savell and Cross, 1988; Kim and Talyor, 2001). Increased marbling improves overall palatability, and increases consumer satisfaction in addition to increasing income through USDA choice and prime quality grade grid incentives (Savell et al., 1987).

Hormonal implants improve growth rate, feed efficiency, and leanness (Hancock et al., 1991; Samber et al., 1996). However, repetitive implant strategies result in lower marbling scores and overall quality grades (Apple et al., 1991; Foutz et al., 1997; Platter et al., 2003). Due to the negative effect of implants on carcass merit any intervention that could increase intramuscular fat deposition in implanted cattle without effecting performance would increase producer profits and consumer acceptance.

Ascophyllum nodosum is a brown seaweed species harvested off the coast of Nova Scotia that is commercially available as a nutritional supplement and feed additive. While the mechanism of action is currently unknown the inclusion of *Ascophyllum nodosum* into beef cattle diets has improved animal health, food safety and carcass quality (Fike et al., 2001; Montgomery et al., 2001; Braden et al., 2004). *Ascophyllum nodosum* supplementation has resulted in improvements in animal health, heat tolerance, immune cell function, increased circulating antioxidant levels, and improves supplemented meat product shelf life, color and marbling score (Zaki et al., 1994; Behrends et al., 2000; Allen et al., 2001; Montgomery et al., 2001; Saker et al., 2001). Beef steers grazing Tasco-EX treated tall fescue (*Festuca arundinacea*) pasture had more marbling at harvest in retail cuts than steers that grazed non-treated

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Table 1. Ingredient composition and chemical analysis of receiving and finishing diets[a]

	d 0 to d 35	d 35 to d 155
Ingredient	%	%
Corn silage (50% grain)	-	52.39
Corn grain (cracked)	47.37	28.03
Corn silage (35% grain)	4.33	-
Cottonseed meal	5.00	-
Cottonseed hulls	6.00	-
Molasses (Cane)	4.00	-
Sweet bran	4.00	-
Wheat hay (sun cured)	10.00	-
Alfalfa hay (mid bloom)	16.80	7.08
TTU Vitamin Premix[b]	2.50	2.50
Chemical composition		
Dry matter (%)	80.97	45.81
CP (%)	12.92	13.25
NEm (Mcal/kg)	1.76	1.85
NEg (Mcal/kg)	1.14	1.22
Calcium (%)	0.75	0.70
Phosphorous (%)	0.34	0.38
Potassium (%)	1.03	1.15
Magnesium (%)	0.27	0.32
Sulfur (%)	0.22	0.20
Sodium (%)	0.18	0.15

[a] Diets balanced to meet NRC requirements.
[b] Contains rumensin and tylan.

Table 2. Approximate composition of *Ascophyllum nodosum* seaweed supplementation[a]

Item	Value	Item	Value
Crude fiber (%)	6.0	Amino acids	
Carbohydrates (%)	52.0	Alanine (%)	5.3
Ash (%)	22.0	Arginine (%)	8.0
Moisture (%)	12.0	Aspartic acid (%)	6.9
Crude protein (%)	6.0	Cystine (%)	trace
Mineral		Glutamic acid	10.0
Aluminum (ppm)	20-100	Glycine (%)	5.0
Arsenic (ppm)	<3	Histidine (%)	1.3
Calcium (%)	1.0-3.0	Isoleucine (%)	2.8
Copper (ppm)	4-15	Leucine (%)	4.6
Iodine (ppm)	<1,000	Methionine (%)	0.7
Magnesium (%)	0.5-1.0	Phenylalanine (%)	2.3
Manganese (ppm)	10-50	Lysine (%)	4.9
Phosphorus (%)	0.1-0.2	Proline (%)	2.6
Potassium (%)	2-3	Serine (%)	3.0
Selenium (ppm)	<1	Threonine (%)	2.8
Sodium (%)	2.4-4.0	Tyrosine (%)	0.9
Sulphur (%)	2.0-2.3	Valine (%)	3.7
Zinc (ppm)	35-100		

[a] Composition determined by Acadian Seaplants Limited, Dartmouth, Nova Scotia.

fescue (Allen et al., 2001b). Further research by Allen et al. (2001b) concluded that application of Tasco increased marbling score and tended to increase USDA quality grade.

Although many studies have shown that *Ascophyllum nodosum* supplementation enhances animal well-being and carcass merit, there has been considerable debate as to the optimal supplementation strategy. Thus, this study's focus was to determine the supplementation period that resulted in the greatest improvement in overall carcass merit.

MATERIALS AND METHODS

Feeding trial

English cross steers (n = 32) and heifers (n = 32) approximately 10 months of age arrived on d 0 of the trial at the Texas Tech University Beef Research Center weighing 317 to 340 kg, respectively. Animals were vaccinated for infectious bovine rhinotracheitis using Pyramid 9® (Fort Dodge; Overland Park, Kansas), blackleg using Ultrabac 7® (Pfizer; New York, NY), bovine respiratory disease using Bovishield Gold® (Pfizer; New York, NY), and dewormed with ivermectin. After a 35 d adjustment period from arrival, cattle were assigned to one of 4 treatment groups, and weighed. Animals were blocked by sex and randomly allocated to 46.5 m^2 dirt pens with four animals per pen. Pens were randomly assigned a treatment with an equal number of pens per treatment (n = 4) and an equal number of male and female pens in each treatment (n = 2). Animals were implanted with Ralgro® (Schering Canada Inc.; Pointe Claire, Quebec) on d 36 of the trial and re-implanted with Revalor-S®+Revalor-H® (Intervet Inc.; Boxmeer, The Netherlands) on d 92 of the trial.

Animals were fed receiving and finishing diets (Table 1) *ad libitum* once a day in incremental phases that began with a corn based receiving diet from d 0 to d 35. Animals were transitioned to a corn silage-based diet containing 13.3% protein on a DM basis on d 35 of the trial to the end of feeding. Control diet was formulated to be isocaloric and isonitrogenous to treatment diets. Treatment diets contained a 2% *Ascophyllum nodosum* supplementation on a DM basis (Table 2). Treatment 1 (trt 1) animals received the basal diet plus 2% *Ascophyllum nodosum* supplementation from d 36 to 50 of the trial. Trt 2 received 2% *Ascophyllum nodosum* supplementation for the final 14 d of the feedlot trial. Trt 3 received 2% *Ascophyllum nodosum* supplementation for d 36 to 50 and the last 14 day of the feedlot trial. A control group received only the base diet throughout the trial. Feed efficiency, body weight, average daily gain, and ultrasound backfat measurements were recorded every 28 d commencing 35 d after arrival.

Carcass measurements

Cattle were determined to be 14 d from slaughter by using pen ADG to calculate a final BW of 554 kg. Once the pens reached an average weight of 554 kg they were shipped 25 km for harvest at a commercial processing facility. Carcass data collected included hot carcass weight (HCW), Longissimus muscle area (LEA), yield grade,

Table 3. Performance characteristics of cattle supplemented with 2% *Ascophyllum nodosum* in a commercial corn based diet

Characteristic	Treatment				SE[d]
	Control -No *Ascophyllum nodosum*	*Ascophyllum nodosum* on d 36-50	*Ascophyllum nodosum* on last 14 d	*Ascophyllum nodosum* on d 36-50 and last 14 d	
Weight (kg)					
d 36	381.5	384.5	388.2	385.9	4.93
d 62	440.5	444.5	446.3	453.2	5.74
d 92	502.1	498.2	499.6	512.3	5.28
d 122	535.9	532.3	531.6	547.5	8.78
d 155	553.8	552.5	544.4	567.1	8.79
ADG (kg/d)					
d 36-d 62	2.27	2.31	2.23	2.59	0.13
d 62-d 92	2.05	1.79	1.78	1.97	0.15
d 92-d 122	1.13	1.14	1.07	1.17	0.17
d 122-d 155	0.55	0.61	0.39	0.60	0.14
Overall ADG	1.45	1.41	1.31	1.52	0.06
Feed efficiency (Feed/gain)					
d 36-d 62	7.11	6.62	7.46	6.30	0.45
d 62-d 92	6.73	7.65	7.79	7.68	0.51
d 92-d 122	11.87	11.79	11.18	11.37	1.91
d 122-d 155	13.93[e]	19.77	29.46	19.14	13.53
Overall FE	9.14	9.08	9.69	9.02	0.36

[a, b, c] Means within a row with different superscripts differ ($p<0.05$).

[d] Pooled standard error of the mean, n = 4.

[e] A pen lost weight during this time period and Feed Efficiency could not be calculated, so it is not included in this calculation.

Table 4. Carcass characteristics of cattle supplemented with 2% *Ascophyllum nodosum* in a commercial corn based diet

Characteristics	Treatment				SE[d]
	Control-No *Ascophyllum nodosum*	*Ascophyllum nodosum* on d 36-50	*Ascophyllum nodosum* on last 14 d	*Ascophyllum nodosum* on d 36-50 and last 14 d	
Hot Carcass Weight, kg	339.5	338.3	334.9	344.3	3.87
Longissimus muscle area (cm^2)	89.40	89.21	83.24	88.52	1.50
Lean color[e]	6.06	6.63	6.00	6.13	0.54
Lean texture[f]	6.44	7.06	6.63	6.75	0.24
Lean firmness[g]	6.44[a]	7.25[b]	6.63[a]	6.69[a]	0.16
Marbling score[h]	473.8[a]	572.5[c]	528.1[b]	528.1[b]	14.78
Quality grade[i]	3.94[a]	5.25[b]	4.56[ab]	4.75[ab]	0.14
Yield grade	2.57	2.54	2.73	2.71	0.12

[a, b, c] Means within a row with different superscripts differ ($p<0.05$).

[d] Pooled standard error of the mean, n = 4.

[e] Lean color is on a scale from 8 to 1, where 8 = extremely bright cherry red and 1= extremely dark red.

[f] Lean texture is on a scale from 8 to 1, where 8 = extremely fine and 1 = extremely coarse.

[g] Lean firmness is on a scale from 8 to 1, where 8 = extremely firm and 1 = extremely soft.

[h] Code: 400 = Slight, 500 = Small.

[I] Code: 4 = Low choice, 5 = Average choice.

marbling score, lean color, lean texture, and lean firmness (Miller et al., 1997; Moon, 2006).

Statistical analyses

Data was analyzed as a randomized block design, blocked by sex using mean separation. For performance measurements pen was used as the experimental unit, and for carcass measurements animal was used as the experimental unit.

RESULTS

There were no differences for any of the growth traits including weight, ADG, or feed efficiency (Table 3). Carcass characteristics, including yield grade, hot carcass weight (HCW), lean color, LM area (LEA), and texture, revealed no significant differences (Table 4). Marbling and firmness scores were found to differ among treatments ($p<0.05$). Trt 1 had 8.25% firmer lean muscle ($p<0.05$) than all other groups (Table 4). The control group had a lower marbling score (473.75; $p<0.05$) than all other treatment groups (572.50, trt1; 528.12, trt 2 and trt 3; Table 4). Although all treatments were higher for marbling than the control, trt 1 was found to have the higher marbling score than all other groups (572.50; $p<0.05$; Figure 1). Naturally, it was found that as marbling score increased there was a

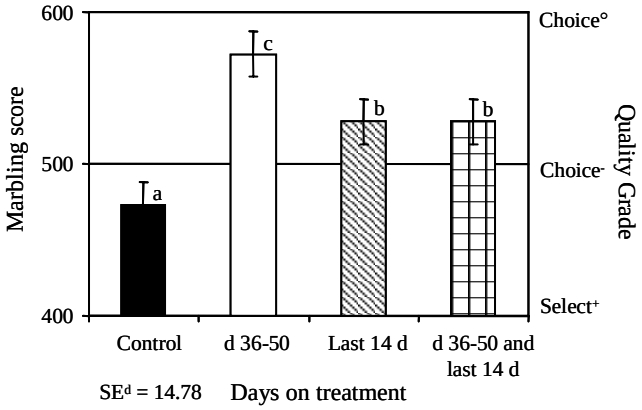

Figure 1. Distribution of marbling scores and corresponding quality grades* of treatment groups. * Correspondnig quality grades relate to A maturity cattle. [a, b, c] Effect of *Ascophyllum nodosum* different superscripts differ ($p<0.05$). [d] SE = Pooled Standard error of the mean, n = 4 for each bar where pen is experimental unit.

similar effect on USDA quality grade. Trt 1 had a higher quality grade (5.25) than the control (3.94) group ($p<0.05$), but did not differ from trt 2 (4.56; $p = 0.105$) and trt 3 (4.75; $p = 0.236$) where high Select = 4, and low Choice = 5. Trt 2 did not differ from trt 3 ($p = 0.655$), or the control group ($p = 0.140$) for quality grade. However, trt 3 did tend to differ ($p = 0.057$) from the control group for quality grade. Eighty-one percent of the cattle in trt 1 graded Choice or better, and had 6% of the animals grade Prime. For trt 2 and trt 3, 62.5% of the cattle graded Choice or better, and only 25% of the control group graded Choice or better. The control group had 25% Choice, 62.5% Select; trt 1 had 75% Choice, 18.8% Select; trt 2 had 62.5% Choice, 25% Select and trt 3 had 62.5% Choice and 37.5% Select. Overall, treatment groups had a 39.6% increase in Choice quality grade and a 37.5% decrease in Select quality grade when compared to the control group.

DISCUSSION

In previous studies using *Ascophyllum nodosum* supplementation on pasture it was found that no differences exist in any animal performance characteristics including weight gain, ADG, and feed efficiency between animals (Allen et al., 2001). This is consistent with our results, where we feed *Ascophyllum nodosum* to finishing cattle resulting in no effect on weight gain or feed efficiency during the finishing trial ($p>0.05$). The only difference detected in this study was that cattle fed *Ascophyllum nodosum* from d 36 to 50 had a significant increase in lean firmness ($p<0.05$), which was not reported in other studies utilizing *Ascophyllum nodosum* (Allen et al., 2001; Montgomery et al., 2001).

Hormonal implanting of cattle usually results in improved growth rate, feed efficiency, and leanness of cattle, as well as a reduction in marbling, quality grades and overall carcass merit (Hancock et al., 1991; Duckett et al., 1996; Moseley et al., 2003). The main focus of this study was to determine which supplementation period maximized the effects of *Ascophyllum nodosum* on intramuscular fat deposition in cattle while getting the performance advantages of implants. Roeber et al. (2000) found a reduction in marbling score in implanted cattle when compared to non-implanted cattle. In this study, all cattle consuming the treatment diet had superior carcass merit as compared to controls, indicating *Ascophyllum nodosum* may be able to overcome the reduction in marbling score associated with hormonal implants. However there was no decrease in animal performance indicating that *Ascophyllum nodosum* does not interfere with the mechanism of action associated with hormonal implants. These data indicate that *Ascophyllum nodosum* supplementation allowed animals to take advantage of implant benefits in performance while improving carcass merit. Twenty-five percent of the control group graded Choice or better, whereas the treatment group achieved a 69% Choice or higher quality grade value. Overall, the supplementation of *Ascophyllum nodosum* resulted in a 44% increase in quality grade. However, trt 1 had a higher marbling score when compared to all other treatments ($p<0.05$) and all treatments had a higher marbling when compared to the control group ($p<0.05$). This finding agrees with those of Allen et al. (2001), who reported an increased marbling score for *Ascophyllum nodosum*-supplemented animals. Animals supplemented from d 36 to 50 (trt 1) had growth performance similar to all other treatments; however, trt 1 resulted in the significantly greatest improvement in carcass merit. Other research has found improvements in quality grade but a feeding strategy was not suggested (Allen et al., 2001; Montgomery et al., 2001; Braden, 2003). This study indicates that early feeding of *Ascophyllum nodosum* from d 36-50 of the feedlot period results in the greatest improvement in carcass merit. It has been suggested that altered lipid metabolism or energy is the cause of the increase in carcass merit of cattle supplemented with *Ascophyllum nodosum* (Montgomery et al., 2001). As previously stated, the inclusion of *Ascophyllum nodosum* in cattle diets improves immune function and overall animal health (Saker et al., 2001). This reduction in stress may also be implicated in the improvements in carcass merit. The reduction in stress and improved immune function could repartition nutrients so that the energy requirements of the immune system are reduced, and excess energy could be used for growth and fat deposition (Saker et al., 2001; Brown et al., 2006). Although further research is required to elucidate the mechanism, this study has determined the ideal strategy for *Ascophyllum nodosum* supplementation in aggressively implanted English crossbred steers and heifers.

IMPLICATIONS

Ascophyllum nodosum supplementation at 2% of a commercial grain based feedlot diet significantly improved overall quality grade and carcass merit. In addition to this, feeding *Ascophyllum nodosum* on d 36 to 50 in the feedlot period maximized carcass performance of implanted feedlot cattle with no detrimental effect on performance. Therefore, *Ascophyllum nodosum* supplementation is an economically viable method for overcoming the negative carcass characteristics traditionally observed in implanted feedlot cattle.

REFERENCES

Allen, V. G., K. R. Pond, K. E. Saker, J. P. Fontenot, C. P. Bagley, R. L. Ivy, R. R. Evans, C. P. Brown, M. F. Miller, J. L. Montgomery, T. M. Dettle and D. B. Wester. 2001. Tasco-Forage: III. Influence of a seaweed extract on performance, monocyte immune cell response, and carcass characteristics in feedlot-finished steers. J. Anim. Sci. 79:1032-1040.

Allen, V. G., K. R. Pond, K. E. Saker, J. P. Fontenot, C. P. Bagley, R. L. Ivy, R. R. Evans, R. E. Schmidt, J. H. Fike, X. Zhang, J. Y. Ayad, C. P. Brown, M. F. Miller, J. L. Montgomery, J. Mahon, D. B. Wester and C. Melton. 2001a. Tasco: Influence of a brown seaweed on antioxidants in forages and livestock - A review. J. Anim. Sci. 79(E. Suppl.):E.21-31.

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.

Behrends, L. L., J. R. Blanton, Jr., M. F. Miller, K. R. Pond and V. G. Allen. 2000. Tasco supplementation in feedlot cattle: Effects on pathogen loads. J. Anim. Sci. 78(Suppl. 1):106 (Abstr.).

Braden, K. W. 2003. Effects of 2% *Ascophyllum nodosum* on carcass characteristics, retail display, and microbial loads of feedlot steers. M. S. Thesis, Texas Tech University, Lubbock.

Braden, K. W., J. R. Blanton Jr., V. G. Allen, K. R. Pond and M. F. Miller. 2004. *Ascophyllum nodosum* Supplementation: A preharvest Intervention for reducing *Escherichia coli* O157:H7 and *Salmonella spp.* in feedlot steers. J. Food Prot. 67:1824-1828.

Brown, Jr., A. H., P. K. Camfield, R. T. Baublits, F. W. Pohlman, Z. B. Johnson, C. J. Brown, G. T. Tabler and B. A. Sandelin. 2006. Effects of size and rate of maturing on carcass composition of pasture- and feedlot- developed steers. Asian-Aust. J. Anim. Sci. 19(5):661-671.

Duckett, S. K., D. G. Wagner, F. N. Owens, H. G. Dolezal and D. R. Gill. 1996. Effects of estrogenic and androgenic implants on performance, carcass traits, and meat tenderness in feedlot steers: A review. Prof. Anim. Sci. 12:205.

Fike, J. H., V. G. Allen, R. E. Schmidt, X. Zhang, J. P. Fontenot, C. P. Bagley, R. L. Ivy, R. R. Evans, R. W. Coelho and D. B. Wester. 2001. Tasco-Forage: I. Influence of a seaweed extract on antioxidant activity in tall fescue and in ruminants. J. Anim. Sci. 79:1011-1021.

Foutz, C. P., H. G. Dolezal, T. L. Gardner, D. R. Gill, J. L. Hensley, and J. B. Morgan. 1997. Anabolic implants effects on steer performance, carcass traits, subprimal yields, and longissimus muscle properties. J. Anim. Sci. 77:1256-1265.

Hancock, D. L., J. F. Wagner and D. B. Anderson. 1991. Effects of estrogens and androgens on animal growth. In: (Ed. A. M. Pearson and T. R. Dutson) Growth Regulation in Farm Animals: Advances in Meat Research. pp. 7:235-297. Elsevier Applied Science, New York.

Kim, J. J. and J. Taylor. 2001. Evaluation of beef carcass and palatability traits and prediction of tenderness in a cross of Bos Indicus Bos Taurus cattle. Asian-Aust. J. Anim. Sci. 14:1621.

Miller, M. F., C. R. Kerth, J. W. Wise, J. L. Lansdell, J. E. Stowell, and C. B. Ramsey. 1997. Slaughter Plant Location, USDA quality grade, external fat thickness, and aging time effects on sensory characteristics of beef loin strip steak. J. Anim Sci. 75:662-667.

Montgomery, J. L., V. G. Allen, K. R. Pond, M. F. Miller, D. B. Wester, C. P. Brown, R. Evans, C. P. Bagley, R. L. Ivy and J. P. Fontenot. 2001. Tasco-Forage: IV. Influence of a seaweed extract applied to tall fescue pastures on sensory characteristics, shelf life, and vitamin E status in feedlot-finished steers. J. Anim. Sci. 79:884-894.

Moon, S. S. 2006. The effect of quality grade and muscle collagen contents and tenderness of intramuscular connective tissue and myofibrillar protein for hanwoo beef. Asian-Aust. J. Anim. Sci 19(7):1059-1064.

Moseley, W. M., D. M. Meeuwse, J. F. Boucher, K. J. Dame and J. W. Lauderdale. 2003. A dose-response study of melengestrol acetate on feedlot performance and carcass characteristics of beef steers. J. Anim. Sci. 81:2699-2703.

Platter, W. J., J. D. Tatum, K. E. Belk, J. A. Scanga and G. C. Smith. 2003. Effects of repetitive use of hormonal implants on beef carcass quality, tenderness, and consumer ratings of beef palatability. J. Anim. Sci. 81:984-996.

Roeber, D. L., R. C. Cannell, K. E. Belk, R. K. Miller, J. D. Tatum, and G. C. Smith. 2000. Implant strategies during feeding: Impact on carcass grades and consumer acceptability. J. Anim. Sci. 78:1867-1874.

Saker, K. E., V. G. Allen, J. P. Fontenot, C. P. Bagley, R. L. Ivy, R. R. Evans and D. B. Wester. 2001. Tasco-Forage: II. Monocyte immune cell response and performance of beef steers grazing tall fescue treated with a seaweed extract. J. Anim. Sci. 79:1022-1031.

Samber, J. A., J. D. Tatum, M. I. Wray, W. T. Nichols, J. B. Morgan and G. C. Smith. 1996. Implant program effects on performance and carcass quality of steer calves finished for 212 days. J. Anim. Sci. 74:1470-1476.

Savell, J. W., R. E. Branson, H. R. Cross, D. M. Stiffler, J. W. Wise, D. B. Griffin and G. C. Smith. 1987. National Consumer Retail Beef Study: Palatability evaluations of beef loin Steaks tat differed in marbling. J. Food Sci. 52:517-519, 532.

Savell, J. W. and H. R. Cross. 1988. The role of fat in the palatability of beef, pork, and lamb. Designing Foods: Animal Product options in the Marketplace. pp. 345-355. National Academy Press, Washington, DC.

Tatum, J. D., G. C. Smith and Z. L. Carpenter. 1982. Interrelationships between marbling, subcutaneous fat thickness and cooked beef palatability. J. Anim. Sci. 34:777-784.

Zaki, M. A., A. M. Nour, E. Omar and A. E. Tag El-Din. 1994. The use of seaweed meal in feeding common carp. Asian-Aust. J. Anim. Sci. 7(2):183.