Evaluation of Warm Season Annuals for Forage Finishing in the Piedmont Region on Animal Performance and Meat Quality

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Abstract

The objective of this study was to evaluate the effects of pearl millet (PM), pearl millet plus crabgrass (PMCG), brown midrib (BMR) sorghum sudangrass (BMR SxS), and sorghum sudangrass (SxS) on animal production and meat quality characteristics. Cross-bred steers (n=32) were stratified by weight, randomly assigned to a treatment and forage finished for 83 d. Body weight was recorded on d 0 and 83. All pastures were managed for rotational stocking. Forage samples for mass and nutritive value were collected on d 0 and every 14 d thereafter. On d 86, all animals were harvested, and carcass data was collected for yield and quality determination as well as objective carcass fat and lean color scores (CIE L*, a*, b*) and subjective fat and lean color scores. The left boneless short-loin was removed from each carcass and held in vacuum packaging for 17 d of aging. Following aging, short-loins were fabricated into 2.54-cm steaks and analyzed for proximate analysis, fatty acid analysis, slice-shear force, sensory analysis, and retail shelf-life measuring subjective color, objective color and lipid oxidation. No treatment differences in ADG were found ($P = 0.30$). Carcasses from steers grazing all treatments had similar HCW, %KPH, REA, 12th rib fat thickness, and yield grade ($P > 0.17$). There were no differences between treatments for carcass marbling scores ($P > 0.12$). No treatment differences were observed for objective color scores of lean ($P > 0.50$) and fat ($P > 0.26$), or subjective lean color scores ($P > 0.34$). Carcasses from PMCG had a greater overall maturity (A^{80}) than SxS ($P < 0.01$; A^{60}) and PM ($P = 0.03$; A^{70}) due to PMCG carcasses having a greater lean maturity ($P < 0.01$) than carcasses from other treatments. Subjective fat color readings of SxS carcasses were more yellow in color than all other treatments ($P \leq 0.03$). Sensory panel evaluation found BMR SxS and SxS to have a stronger off-flavor ($P > 0.02$) when compared to PMCG, with PM being intermediate. No differences in tenderness ($P = 0.13$), juiciness ($P = 0.71$) or beef flavor intensity ($P = 0.36$) were found. Slice shear force evaluation of tenderness found no differences in tenderness ($P = 0.36$). No overall differences ($P = 0.19$) in TBARS values measuring lipid oxidation were found between treatments following the 7 d of retail display. Objective color findings indicate steaks from SxS were lighter (L*) on d 1 ($P = 0.03$) than PM and BMR SxS, with PM having the darkest lean color. Objective color on d 3 showed PM having a lighter ($P = 0.03$), more yellow lean color ($P = 0.02$) than other treatments. Additionally, objective color on d 3 found PM to be redder or more red in color (a*), followed by PMCG, BMR SxS, and SxS ($P = 0.04$). No other differences in objective color were found. These data indicate the four forage systems can be used in warm season annual forage finishing programs without affecting animal performance and having minimal effects on carcass characteristics.

Problem Statement

With escalating feed cost associated with traditional systems of producing beef, many cattle producers are searching for opportunities to add value to their operation. Concurrently, consumer interest in locally produced food and forage-fed beef is growing (Lacy, et al., 2007).

Considering Georgia's environment allows for forage production twelve months out of the year, this creates an excellent opportunity for cattle producers to maintain their economic livelihood.

However, there are several hurdles facing ranchers considering forage-finished beef production. First, forage-based programs can take as much as twelve months longer to reach desired harvest weights compared to grain-based programs. Secondly, meat from forage-finished beef is associated with decreased marbling, decreased quality grades, decreased sensory panel ratings and a more yellow fat when compared to grain-finished beef (Leheska, et al. 2008; Bowling et al., 1978). Finally, the hot humid summers in the Southeast make it difficult for cattle to gain weight through the summer on typical forages.

Previous research has shown higher quality forages have the potential to increase forage intake, animal performance with less impact on carcass characteristics (Jung and Allen, 1995; Leheska et al., 2008). Warm-season annual forage, such as pearl millet, sorghum-sudangrass, brown midrib sorghum-sudangrass, and crabgrass are high quality forages that can fill in gaps in availability of nutrients for grazing cattle. These forages can be established quickly compared to other forages and have the potential for high yields within a short time period (Miller, 1984). Therefore, opportunity lies in utilizing these forages to add weight economically through the summer for cattle to be harvested in late summer/early fall. However data is limited comparing these forage systems for forage-finishing beef operations.

Consequently, this research aims to evaluate the effect of warm season annual forages in the Piedmont region on animal performance, carcass characteristic, and meat quality of beef steers. Without this knowledge, producers are neglected valuable information that may lead to producing a higher gaining, higher quality product economically. This goal of this experiment is to answer the question "What do I plant?" for Georgia beef producers operating a grass-finished operation.

Creative Research Approach

This grazing component of this experiment was conducted from May 2013 through September 2013 at the J. Phil Campbell Sr. Research and Education Center in Watkinsville, Georgia. Sixteen 0.73 ha pastures were blocked by previous land management (conventional tillage, no-tillage, or permanent pasture) and randomly assigned one of four warm-season annual forage treatments. Treatments consisted of 'Tifleaf 3' pearl millet (PM; *Pennisetum glaucum)*, 'Tifleaf 3' pearl millet and 'Red River' crabgrass (PMCG; *Digitaria sanguinalis)*, 'Honey Graze BMR' brown midrib sorghum sudangrass (BMR SxS; *Sorghum bicolor x S. bicolor ssp. drummondii*) and 'Sugar Grazer' sorghum sudangrass (SxS; *Sorghum bicolor x S. bicolor ssp. drummondii*). These treatments are ideal for forage finishing in Georgia, as sorghum sudangrasses are drought tolerant and brown midrib varieties are more digestible. Pearl millet is quick to mature, with low water requirements (Ahlgren, 1956). These resilient forages are capable of withstanding the potentially harsh weather of the Southeast, while the high palatability of crabgrass (Miller, 1984) is complementary to the hardiness of pearl millet, potentially increasing forage intake. Pastures were managed using rotational stocking, and forage samples for mass and nutritive value were collected on d 0 and every 14 d thereafter.

Thirty-two cross-bred beef steers (avg BW 386 ± 9.5 kg) were initially utilized as experimental animals, and were stratified by weight and randomly assigned a pasture. Two steers were removed from the experiment due to temperament. Additional steers were utilized in "put and take" grazing, which were non-experimental animals that aided in maintaining grazing pressure, forage height and forage quality. Body weight was recorded on d 0 and 83. On d 86, all animals were harvested at White Oak Pastures (Bluffton, Georgia), and carcass data was collected for yield and quality determination. Additionally, objective (CIE L*, a*, b*) and subjective color carcass fat and lean color were collected 24 hr postmortem. The boneless short-loin from the left side of each carcass was removed, vacuum packaged, and held for 17 d for aging. Following aging, boneless short-loins were cut into 2.54-cm steaks for use in proximate analysis, sensory analysis, analysis of fatty acids, slice-shear force, and retail shelf-life stability. Retail shelf-life analysis was conducted in open topped retail display coolers, continuously maintained at appx 1°C, under appx. 1810 to 2000 lux for 7d, with objective and subjective color, and lipid oxidation analyzed on d 0, 1, 3, 5 and 7.

Results

No differences between treatments (P = 0.30*)* were found for average daily gain, which was 1.10, 0.87, 0.1.02, and 0.79 kg/hd/d for BMR SxS, PM, PMCG, and SxS, respectively. Carcasses from PMCG had a greater overall maturity (A^{80}) than SxS ($P < 0.01$; A^{60}) and PM ($P = 0.03$; A^{70}) due to PMCG carcasses having a greater lean maturity ($P < 0.01$) than carcasses from other treatments. No differences between treatments were found for carcass marbling scores ($P > 0.12$). Subjective fat color readings of SxS carcasses were more yellow in color than all other treatments ($P \leq 0.03$). Carcasses from steers grazing all treatments had similar HCW, %KPH, REA, 12^{th} rib fat thickness, and USDA calculated yield grade ($P > 0.17$). No treatment differences were observed for objective color scores of carcass lean ($P > 0.50$) and fat ($P > 0.26$), or subjective carcass lean color scores ($P > 0.34$). Sensory panel evaluation found BMR SxS and SxS to have a stronger off-flavor ($P > 0.02$) when compared to PMCG, with PM being intermediate. No differences in tenderness (P = 0.13), juiciness (P = 0.71) or beef flavor intensity (P = 0.36) were found. Slice shear force evaluation of tenderness concurred with sensory panel findings of no differences in tenderness (P = 0.36). No overall differences (P = 0.19) in Thiobarbituric acid reactive substances (TBARs; a measure of lipid oxidation) values were found between treatments following the 7 d shelf life study. Objective color findings indicate steaks from SxS were lighter (L*) on d 1 (P = 0.03) than PM and BMR SxS, with PM having the darkest lean color. Objective color on d 3 showed PM having a lighter (P = 0.03), more yellow lean color (P = 0.02) than other treatments. Additionally, objective color on d 3 found PM to be redder or more red in color (a*), followed by PMCG, BMR SxS, and SxS (P = 0.04). No other differences in objective color were found. Analysis of forage quality, percent fat and fatty acids has yet to be conducted.

Conclusions

Based on these findings, producers looking to finish cattle on forage systems may minimize off-flavors by utilizing PM or PMCG forages systems, and may minimize yellowness in fat by utilizing BMR SxS, PM, or PMCG. These forage systems may be ideal for producers looking to sell their product as whole muscle product in grass-finished markets. However, with few

differences found between treatment for production, shelf-life and sensory aspects, these data indicate the four forage systems can be used in warm season annual forage finishing programs without affecting animal performance and having minimal effects on carcass characteristics.

Table 1. Least squares means of animal performance and carcass yield characteristics of steers forage-finished on brown midrib sorghum sudangrass, pearl millet, pearl millet plus crabgrass and sorghum sudangrass.

	Treatment				
Trait	BMR SxS	PM	PMCG	SxS	SEM
Live Animal Performance					
Beginning Weight, kg	349.7	353.9	346.3	356.4	4.19±0.84
Final Weight, kg	440.7	425.8	430.3	421.2	11.0±2.2
Average Daily Gain, kg	1.10	0.87	1.02	0.79	0.12±0.03
Carcass Characteristics					
Hot Carcass Weight (kg)	235.5	236.9	231.6	232.2	4.8±1.0
Dressing Percentage %	53.49	55.79	53.76	55.08	1.00±0.20
Rib Eye Area (cm^2)	60.4	63.5	57.6	60.8	2.8±0.5
Kidney Pelvic Heart Fat %	1.44	1.19	0.98	1.06	0.14±0.03
Back Fat Thickness (cm)	0.38	0.20	0.25	0.20	0.08
Yield Grade	2.13	1.77	2.04	1.84	0.19±0.04

Table 2. Carcass quality characteristics of steers forage finished on brown midrib sorghum sudangrass, pearl millet, pearl millet plus crabgrass and sorghum sudangrass.

	Treatment				
Trait	BMR SxS	PM	PMCG	SxS	SEM
Marbling[1]	403.75	303.75	339.72	340.00	28.33±5.72
Lean Maturity[2]	210.00[b]	211.25[b]	240.00[a]	198.75[b]	6.96±1.40
Skeletal Maturity[2]	137.50	128.75	127.78	123.75	4.37±0.88
Overall Maturity[2]	157.5[a]	151.25[b]	164.58[a]	145.00[b]	3.42±0.70
Subjective Lean Color[3]	5.13	5.25	5.69	4.88	0.29±0.05
Subjective Fat Color[4]	2.50[b]	3.13[b]	3.44[b]	4.88[a]	0.40±0.08
Firmness[5]	2.44	2.88	2.97	2.75	0.31±0.06
Texture[6]	1.75	1.50	2.19	1.50	0.20±0.05
Obj Fat Color					
L*[7]	76.29	73.5	73.45	72.31	1.47±0.30
a*[8]	5.38	7.00	9.29	7.24	1.22±0.25
b*[9]	21.43	21.36	23.52	23.41	1.71±0.35
Obj Lean Color					
L*[7]	33.34	32.63	32.59	33.85	0.66±0.13
a*[8]	20.39	19.87	19.86	20.57	0.81±0.17
b*[9]	6.07	5.75	5.96	6.59	0.44±0.09

[abc] Means within a row without a common superscript differ ($P < 0.05$).

[1]Marbling scores (100=practically devoid, 200=traces, 300=slight, 400=small, 500=modest, 600=moderate, 700=slightly abundant, 800=moderately abundant).

[2]Maturity scores (100=A, 200=B, 300=C, 400=D, 500=E).

[3]Subjective lean color (1=Extremely dark red, 2=Dark red, 3=Moderately dark red, 4=Slightly dark cherry red, 5=Slightly bright cherry red, 6=Moderately bright cherry red, 7=Bright cherry red, 8=Extremely bright cherry red).

[4]Subjective fat color (1=White, 2=Creamy white, 3=Slightly yellow, 4=Moderately yellow, 5=Yellow).

[5]Firmness (1 = very firm, 2 =firm, 3=slightly firm, 4=slightly soft, 5=soft).

[6]Texture (1 = very fine, 2=fine, 3=slightly fine, 4=slightly course, 5=coarse).

[7]0= black, 100= white.

[8]Greater values indicate increased redness.

[9]Greater values indicated increased yellowness.

Table 3. Objective and subjective shelf-life data of steers forage finished on brown midrib sorghum sudangrass, pearl millet, pearl millet plus crabgrass and sorghum sudangrass.

		Treatment				
Item		BMR SxS	PM	PMCG	SxS	SEM
Objective Color						
L*[1]	d 0	29.01	30.38	29.71	29.44	1.51±0.3
	d 1	36.31[bc]	46.78[ab]	31.88[c]	51.44[a]	4.69±0.95
	d 3	9.51[b]	15.97[a]	10.47[b]	8.65[b]	1.73±0.35
	d 5	21.79	22.10	21.19	19.66	1.74±0.35
	d 7	19.14	20.51	10.17	20.12	4.06±0.82
a*[2]	d 0	27.75	28.77	28.83	28.38	1.06±.021
	d 1	27.6	26.28	27.59	26.17	1.84±0.37
	d 3	13.13[bc]	17.68[a]	14.30[ab]	12.82[c]	1.22±0.24
	d 5	15.88	13.93	16.66	14.4	1.42±0.28
	d 7	12.96	15.45	10.29	12.00	1.55±0.32
b*[3]	d 0	21.96	22.71	23.22	22.72	1.21±0.25
	d 1	21.73	22.42	20.58	22.23	0.96±0.19
	d 3	8.27[b]	12.72[a]	8.77[b]	7.60[b]	1.17±0.24
	d 5	12.09	10.97	12.64	11.01	1.19±0.24
	d 7	9.38	9.38	6.91	9.17	1.26±0.25
Subjective Color						
Overall Color[4]	d 0	3.82	4.00	3.75	3.65	0.51±0.11
	d 7	6.08	6.21	6.10	6.23	0.30±0.06
Discoloration[5]	d 0	8	8	8	8	0
	d 7	4.08	5.18	4.56	4.33	0.49±0.09
WPC [4,6]	d 0	3.92	3.95	3.54	3.58	0.49±0.09
	d 7	7.58	7.43	7.66	7.48	0.10±0.02
TBARS	d 0	0.14	0.12	0.15	0.12	0.01
	d 7	0.17	0.15	0.18	0.20	0.02

[abc]Means within a row without a common superscript differ ($P < 0.05$).

[1]0=black, 100=white.

[2]Greater values indicate increased redness.

[3]Greater values indicated increased yellowness.

[4]Color scale (1=Extremely bright cherry red, 2=Bright-cherry red, 3=moderately bright cherry red, 4=slightly bright cherry red, 5=slightly dark cherry-red, 6=moderately dark red, 7=dark red, 8=extremely dark red).

[5]1=Percentage Discoloration (1=90-100%, 2=75-90%, 3=50-75%, 4=25-50%, 5=10-25%, 6=5-10%, 7=0-5%, 8=No discoloration).

[6]Worst point color = a single or combined area of 2 cm^2 on the sample, scale is the same as the color scale above.

Table 4. Sensory characteristics and proximate analysis of steers forage finished on brown midrib sorghum sudangrass, pearl millet, pearl millet plus crabgrass and sorghum sudangrass.

	Treatment				
Item	BMR SxS	PM	PMCG	SxS	SEM
Tenderness[1]	4.81	4.99	3.49	5.05	0.44±0.09
Juiciness[2]	4.50	4.55	4.17	4.63	0.26±0.05
Beef flavor intensity[3]	5.18	5.10	5.13	4.83	0.15±0.03
Off-flavor[4]	1.74[a]	1.42[ab]	1.15[b]	1.57[a]	0.15±0.02
Slice Shear-force	21.35	22.67	30.51	22.79	3.43±0.69
% Purge Loss	2.47	3.12	3.26	2.46	0.40±0.08
Percent Moisture	73.36	74.45	73.37	74.09	0.41±0.08

[abc]Means within a row without a common superscript differ ($P < 0.05$).

[1]1=Extremely tough, 2=very tough, 3=moderately tough, 4=slightly tough, 5=slightly tender, 6=moderately tender, 7=very tender, 8=extremely tender.

[2]1=Extremely dry, 2=very dry, 3=moderately dry, 4=slightly dry, 5=slightly juicy, 6=moderately juicy, 7=very juicy, 8=extremely juicy.

[3]1=Extremely bland, 2=very bland, 3=moderately bland, 4=slightly bland, 5=slightly intense, 6=moderately intense, 7=very intense, 8=extremely intense.

[4]1=None detected, 2=threshold off-flavor, 3=slight off-flavor, 4=moderate off-flavor, 5=very strong off-flavor, 6=extreme off-flavor.

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