FINISHING ON SMALL-GRAIN WINTER ANNUALS OR ALFALFA PASTURE: II. LIPID PROFILES OF BEEF

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Abstract – Effects of finishing on small-grain winter annual or alfalfa pasture on animal growth, carcass and beef characteristics were investigated using 120 Angus steers to determine the potential benefits of different forages on beef quality. Treatments were: 1) cereal rye, 2) triticale, 3) wheat, and 4) alfalfa (Alf). Each treatment consisted of 3 pasture replicates with 10 animals each. Results pointed out that winter annuals and alfalfa differ in quality and lipid composition. Alfalfa and wheat had greater (P < 0.01) intramuscular fat than rye and triticale. In turn, beef from steers grazed on winter annuals had similar lipid profiles, but was different from alfalfa finished beef. No differences were detected in SFA and n-6 PUFA contents (P > 0.234) in the *longissimus* muscle intramuscular fat, but alfalfa beef had greater (P < 0.001) n-3 PUFA, and C18:2c9,t11 conjugated linoleic acid, and lower (P < 0.001) n-3/n6 ratio, than the winter annuals.

Key Words: Feeding strategy; Pasture finishing; Lipid profiles.

I. INTRODUCTION

Interest in pasture finished beef has increased in the recent years as a way to increase intake of leaner meats and healthy fats. Research has repeatedly shown the relevance of forages to improve n-3 PUFA in beef [1, 2, 3]. Few studies, however, have researched the effects of forages on chemical characteristics of beef [4, 5, 6]. Dierking *et al*. [6] detected effects of forage sources on physical and chemical characteristics. Use of small-grain winter annuals during winter and early spring is a common practice in pasture finishing programs of central Argentina. In turn, alfalfa pasture is the common forage on which pasture finishing takes place during spring and summer. Recently, research has described lipid profiles of alfalfa pasture fed beef [4, 5, 6, 7, 8, 9]. No reports have been published on effects of small-grain winter annual species on beef characteristics. This study examined the effects of finishing on pure stands of winter annuals, compared to alfalfa on chemical profiles of Argentinean beef.

II. MATERIALS AND METHODS

The study was carried out at the Agricultural Experiment Station of INTA Anguil, La Pampa, Argentina. One hundred and twenty Angus steers used in 4 treatments: 1) finishing on pure stands of cereal rye (Rye), 2) triticale (Trit), 3) wheat (Wheat) pasture, and 4) alfalfa pasture (Alf). Small-grain winter annuals were planted in 3 pastures replicates randomly distributed on a 75-ha field. Each treatment included 10 animals in each replicate, randomly allocated from a group of spring born steers of similar age and live weight (LW) (551 ± 16.1 d old; 373 ± 17.5 kg). For Alf, 3 alfalfa pasture replicates were randomly chosen from a 35-ha field of 100% alfalfa, previously subdivided in 6 pastures. Thirty fall-born steers of similar age and weight (540 ± 14.5 day old; 374 ± 7.8 kg) and of similar weight to the previous group were randomly selected and allocated to the 3 alfalfa pasture replicates. Small-grain pastures were grazed during 98 days in winter, from June 10th through September 16th. The alfalfa pastures were grazed for 120 days of spring and summer, from October 25th through January 22nd. Paddock size was managed to offer forage above 8% of the animal's LW (on dry matter -DM-basis) daily to avoid restrictions on voluntary intake. Availability was estimated by clipping 5 ½ m2 circle samples and paddock size adjusted accordingly before entering each new paddock. Rotational grazing was implemented using a 2-day grazing: 45-day rest rotation scheme for small grains and a 2-day grazing: 35- day rest

scheme for alfalfa. Paddocks were mowed after each grazing to allow for clean re-growth.

Animals from small-grain treatments and Alf were slaughtered at the end of a 98-day and 120 day period, respectively, when all animals from each group were above 450 kg of LW considered finished by observation of commercial buyers. The slaughter took place at a federally inspected abattoir. After slaughter, carcasses were chilled at 2 ^{o}C. Forty eight hours after slaughter, a rib section encompassing the 10th to 13th ribs was removed from the left side of each carcass. The rib sections were individually identified, bagged, vacuum packaged and kept for an additional 24-hour period at 2 ^{o}C. After chilling for 96 hours, rib sections were frozen and stored at -20 ^{o}C. Analyses were performed to assess forage quality and chemical characteristics of beef.

For lipid analysis, after thawing for 24 hours at 4 ^{o}C and at room temperature for 4 hours, the *longissimus* muscle (LM) portion of the 12th-rib section was used for determination of total lipids and fatty acid (FA) composition. In preparation, samples were trimmed of all external fat, and minced in a blade grinder. Total lipids for FA analysis were extracted from 5-g aliquot samples of LM [10]. Fatty acid methyl esters (FAME) were prepared [11] and measured by gas chromatography of FAME in Chrompack CP 900 apparatus fitted with a flame ionization detector. For FAME separation a capillary column CP-Sil 88 (100 m x 0.25 mm i.d.; Chrompack Inc., Middleburg, The Netherlands) was used, with nitrogen gas as carrier. The oven temperature was programmed at 70 oC for 4 min, increased from 70 to 170 ^{o}C at a rate of 13 ^{o}C/min, and increased from 170 to 200 ^{o}C at a rate of 1 ^{o}C/min. Individual fatty acids were identified by comparing relative retention times to retention times of standards (PUFA-2 Animal Source, Supelco). Results were expressed as percentages of total fatty acids. Main individual fatty acids were grouped in saturated fatty acids (SFA = palmitic (C16:0) + stearic (C18:0)), monounsaturated fatty acids (MUFA = palmitoleic (C16:1) + oleic (C18:1)) and polyunsaturated fatty acids (PUFA = n-3 + n-6 fatty acids), n-3 fatty acids (linolenic (C18:3) + eicosapentaenoic (EPA; C20:5) + docosa-pentaenoic (C22:5; DPA) + docosahexaenoic (DHA; C22:6), n-6 fatty acids (linoleic (C18:2) + di-homo-gamma-linolenic (DGLA; C20:3) + arachidonic (AA; C20:4) + docosatetraenoic (adrenic; C22:4).

Forage availability and residual forage in all paddocks were estimated and forage sampled every 15 days for dry matter (DM) [12], crude protein (CP) [12], acid detergent fiber (ADF) [13], soluble carbohydrates (SCH) [14], and lipid profile. Fat content was determined as ether extract (EE) in a 5-g aliquot, and FA in a 10-g aliquot, following the methodology previously described for beef.

Statistical analyses. Data were analyzed with a model including a complete randomized design with forage source in the main plot, using GLM procedures of SAS [15]. Pasture replicate was the experimental unit. Least square means were generated and separated using PDIFF option of SAS. In addition, orthogonal contrasts were applied to separate effects of Rye vs Trit, Rye and Trit vs Wheat, and winter annuals (Rye, Trit and Wheat) vs Alf.

III. RESULTS AND DISCUSSION

Over the study, winter annuals did not differ ($P > 0.05$) in DM content (Table 1). Treatment Alf had a greater ($P < 0.025$) DM content than the winter annuals. Alf was also greater in CP ($P < 0.008$), and lower in SCH ($P < 0.035$). Wheat had the greatest ($P < 0.05$) SCH over the study. Wheat had the lowest CP SCH^{-1} ratio ($P < 0.05$), followed by Trit and Rye. Treatment Alf had the greatest CP SCH^{-1} ratio, different from the annuals ($P < 0.001$). Overall, contents of EE and FA did not differ ($P > 0.128$) among treatments. Contents of EE and FA declined over time with plant age ($P < 0.01$) (Data not shown). Among the winter annuals, no species effects ($P > 0.115$) were detected on the main single FA in the lipid fraction (Data not shown). Alfalfa beef was different in the lipid profile from beef from the winter annuals. Compared with the annuals, LM of steers from Alf had greater ($P < 0.01$) C16:1, C18:1trans, C18:2c9,t11, C18:3n-3, C20:5n-3, C22:5n-3 and C22:6n-3 and lower C18:1c9 (Data no shown).

No effects ($P = 0.452$) of forage base on SFA and n-6 PUFA ($P = 0.234$) proportions of the LM lipid fraction were detected.

Table 1. Average proximate composition and lipid profiles of forages across the study

	Rye	Trit	Wheat	Alf	SEM[2]	Model	*P*- values for contrasts[4]		
						P-vaue	Rye vs	Rye & Trit	Annuals
						F > Fo	Wheat	vs Wheat	vs Alf
Dry matter, %	19.3[a]	18.1[a]	17.2[a]	25.1[b]	0.98	0.003	0.343	0.662	0.025
Crude protein, %	16.8[a]	16.9[a]	17.6[a]	20.9[b]	0.85	0.022	0.581	0.845	0.008
SCH, %	12.0[b]	13.1[b]	16.6[c]	7.6[a]	0.67	0.001	0.001	0.432	0.035
ADF, %	27.0[a]	26.0[a]	24.6[a]	27.3[b]	0.75	0.044	0.251	0.327	0.012
CP SCH^{-1}	1.48[b]	1.38[b]	1.10[a]	2.8[c]	0.08	0.002	0.584	0.211	0.001
EE, g kg^{-1} DM	26.5	27.5	27.9	28.0	0.67	0.128	-	-	-
FA, g kg^{-1} DM	24.7	25.4	25.8	25.6	0.55	0.173	-	-	-

Rye = Cereal rye; Trit = Triticale; Wheat = Wheat pasture; Alf = Alfalfa pasture.
SCH= Soluble carbohydrates; ADF = Acid detergent fiber; CP = Crude protein; EE = Ether extract; FA = Fatty acids.
[a, b, c,] Means in rows followed by a different superscript differ P < 0.05.

Table 2. Effect of finishing on cereal rye (Rye), triticale (Trit), wheat (Wheat) or alfalfa (Alf) pasture on intramuscular fat content and lipid composition of the *longissimus* muscle of Angus steers

	Rye	Trit	Wheat	Alf	SEM	Model	*P*-values for contrasts		
						P-value	Rye vs	Rye & Trit	Annuals
						F > Fo	Trit	vs Wheat	vs Alf
IMF (g 100^{-1} g)	2.73[a]	3.37[b]	3.61[b]	3.44[b]	0.054	0.001	0.001	0.001	0.012
Proportion of FA (weight, %)									
SFA	45.7	45.8	44.7	45.1	0.394	0.452	-	-	-
MUFA	35.6[b]	35.5[b]	35.9[b]	34.4[a]	0.381	0.024	0.604	0.420	0.004
PUFA	6.8[a]	7.34[a]	7.03[a]	7.79[b]	0.098	0.001	0.023	0.004	0.001
PUFA/SFA	0.15[a]	0.16[b]	0.16[b]	0.17[c]	0.002	0.001	0.088	0.005	0.001
n-6 PUFA	4.63	4.95	4.81	4.71	0.104	0.234	-	-	-
n-3 PUFA	2.17[a]	2.39[a]	2.23[a]	3.08[b]	0.088	0.001	0.337	0.225	0.001
n-6:n-3 ratio	2.13[b]	2.07[b]	2.15[b]	1.53[a]	0.097	0.004	0.801	0.344	0.001
C18:2c9,t11	0.67[a]	0.76[b]	0.73[b]	0.84[c]	0.023	0.004	0.022	0.487	0.002
Content (mg 100^{-1} g of muscle)									
SFA	1.246[a]	1.544[b]	1.613[b]	1.549[b]	0.034	0.001	0.001	0.001	0.022
MUFA	0.971[a]	1.196[b]	1.296[c]	1.180[b]	0.022	0.001	0.001	0.001	0.495
PUFA	0.186[a]	0.247[b]	0.254[b]	0.268[c]	0.006	0.001	0.001	0.001	0.002
n-6 PUFA	0.126[a]	0.167[b]	0.173[b]	0.162[b]	0.005	0.001	0.001	0.001	0.099
n-3 PUFA	0.059[a]	0.081[b]	0.080[b]	0.106[c]	0.004	0.001	0.002	0.001	0.001
C18:2c9,t11	0.018[a]	0.026[b]	0.026[b]	0.029[c]	0.001	0.001	0.001	0.005	0.001
Content (mg 100^{-1} g of muscle) using IMF as a covariate in the model									
SFA	1.501	1.505	1.469	1.481	0.016	0.430	-	-	-
MUFA	1.170[b]	1.166[b]	1.181[b]	1.129[a]	0.015	0.033	0.676	0.169	0.011
PUFA	0.223[a]	0.241[bc]	0.231[b]	0.256[c]	0.003	0.001	0.186	0.054	0.001
n-6 PUFA	0.152	0.163	0.158	0.15[5]	0.004	0.820	-	-	-
n-3 PUFA	0.071[a]	0.079[a]	0.073[a]	0.101[b]	0.004	0.001	0.657	0.183	0.001
C18:2c9,t11	0.022[a]	0.024[a]	0.024[a]	0.028[b]	0.001	0.026	0.428	0.514	0.005

n = 3 (pasture replicates); 3 pasture units $treatment^{-1}$ (10 animals in each pasture replicate).
Rye = Cereal rye; Trit = Triticale; Wheat = Wheat pasture; Alf = Alfalfa pasture.
IMF = Intramuscular fat; FA= Fatty acids; SFA = Saturated fatty acids; MUFA = Mono-unsaturated fatty acids; PUFA = Poly-unsaturated fatty acids; n-3 = Ω-3 fatty acids; n-6 = Ω-6 fatty acids.
[a, b, c,] Means in rows followed by a different superscript differ P < 0.05.

Treatment Alf had greater ($P < 0.001$) n-3 PUFA and total PUFA, and lower MUFA ($P < 0.05$) concentrations in the FA traction, lower ($P < 0.001$) n-3/n-6 ratio, and a greater ($P < 0.001$) contribution of C18:2c9,t11 than the annuals. Differences among winter annuals were present but minimal, compared with alfalfa. Contents of lipid fractions in the muscle (mg 100^{-1} g) varied depending on IMF content. Rye had the lowest contents of most FA groups ($P < 0.05$). Including IMF as covariate in the model yielded similar results in FA groups as proportions of total FA.

IV. CONCLUSION

Forage from small-grain winter annuals and alfalfa are different in nutrient composition and lipid composition, which may in part reflect in lipid profiles of beef. Finishing cattle on small-grain winter annuals or alfalfa pasture generate different lipid profiles in the IMF of LM. Intramuscular lipid profiles from alfalfa finished beef would have greater PUFA a lower n-6 $n\text{-}3^{-1}$ ratio and slightly greater content of C18:2c9,t11 than from winter annuals. Winter annuals would generate similar FA profiles

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