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COMPARISON OF POSTWEANING FINISHING EFFICIENCY OF THREE BIOLOGICAL TYPES OF STEERS

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ABSTRACT

Twelve Chianina cross (CC) steers, 17 Angus cross (AC)steers, and 17 Holstein (HOL) steers were individually fed a 90% concentrate diet from a mean postweaning age of 217 d to an estimated rib fat thickness of 10.2 mm to determine postweaning finishing efficiency. Two steers of each biological type were slaughtered on day 1 of the trial. Rib sections were made from the carcasses of initial and terminal slaughter steers and determinations for bone, fat, and protein were made. Initial frame score for the AC steers (4.2) was significantly less than for either the CC steers (6.9) or the HOL steers (8.1). Final weight of the AC steers (405 kg) was significantly lighter than either the HOL steers (456 kg) or the CC steers (489 kg). The AC steers achieved 10.2 mm rib fat thickness in significantly less time (74 d) than did the CC steers (127 d). Even after 211 d on feed, the HOL steers had less than 10.2 mm rib fat, but were slaughtered as their weight nor initial frame score was not different ($P<.05$) than the CC steers. No significant differences in protein content of the longissimus muscle between steer types were observed between initial and terminal slaughter steers. The HOL steers had significantly more bone at slaughter than either the AC or CC steers. Percentage fat at terminal slaughter was different ($P<.05$) between all 3 biological types being 22.07, 19.22, and 16.72 for AC, CC, and HOL steers, respectively. Both the AC and CC steers had significantly higher average daily gain than the HOL steers. Average daily feed intakes were different ($P<.05$) between all 3 steer types being 10.26, 9.20, and 7.97 kg for CC, AC, and HOL steers, respectively. Feed required per unit of lean carcass weight gain was different ($P<.05$) between all 3 steer types. The HOL steers required more ($P<.05$) feed per unit increase in rib fat than either the AC or CC steers. This study indicates that medium-frame AC sters are more efficient than large-frame CC steers and that HOL steers are less efficient than medium-frame AC or large-frame CC steers.

INTRODUCTION

There is considerable debate today in the beef industry regarding optimum cattle size and economic efficiency. Many cattle feeders have the opinion that cattle can have too large a frame to be economically profitable. These cattlemen believe that because cattle are larger in frame they have a higher energy requirement for maintenance and therefore, inefficient feed to gain ratios. Other cattlemen oppose small- or medium-frame cattle because they mature too quickly and become too fat before reaching the desired market weight, therefore, resulting in lower net dollar returns.

Kleiber (1975) demonstrated the theory that all animals have the same efficiency of production (calories of body tissue produced per calorie of feed intake) when taken to the same composition end point (ratio of body lean to body fat).

Totusek (1981) suggests that when steers of different frame sizes are marketed at the same carcass grade, there are no differences in efficiencies of production (cost per kg of gain). Crickenberger and Black (1976) noted that larger-frame cattle may be less efficient than medium-frame cattle because they have higher daily maintenance feed costs. In a separate study, Crickenberger et al. (1978) observed only small differences in energetic efficiency between the beef breeds or crossbreds, but they found Holsteins to be less efficient than beef breeds. However, Thonney et al. (1981) observed that Holstein cattle grew faster and more efficiently than small-framed Angus cattle when compared at the same weight.

To accurately compare frame sizes and breeds of cattle for economic advantage in the feedlot; rate of gain, energetic efficiency and carcass traits among types should be examined when cattle care fed to similar carcass composition. These data are needed to characterize changes in growth rate and feed efficiency of cattle of varying biological types. This research was conducted to study the post-weaning finishing efficiency of three biological types of cattle: large-frame Chianina cross steers, medium-frame Angus cross steers, and Holstein steers.

MATERIALS AND METHODS

The steers in this study originated from the Illinois State University beef and dairy herds. The dams of both the CC and AC steers were mature 6- to 8-yr old cows of small to medium frame consisting of Angus-Hereford ancestry. The CC steers were sired by one full blood Chianina bull representative of cattle of large mature size. The AC steers were sired by two purebred Angus bulls representative of cattle of medium frame size. The beef steers were born during a 60-day calving interval and were reared on their dams in confinement pens until weaning. The beef steers were fed a creep feed (diet 1) ad libitum from birth through weaning until trial initiation (table 1). The Holstein steers were separated from their dams at 3 days of age and reared in individual stalls on milk replacer until two months of age. At two months of age the HOL steers were placed in one confinement pen and fed diet 1, ad libitum, until trial initiation. No record of feed consumption was kept until trial initiation.

Immediately following weaning of the beef calves, 12 large frame steers of Chianina × Angus-Hereford breeding, 17 medium frame steers of Angus × Angus-Hereford breeding, and 17 Holstein steers were selected for this study. Two steers of each biological type were randomly selected for slaughter and carcass evaluation while the remaining steers were randomly allotted (within biological type) to one of three pens (table 2). Each pen contained a Model 4000B pin-pointer (Rhea, 1979) capable or recording individual feed consumption. Each pen was partially covered, contained a concrete floor, and was bedded with corn stalks.

All steers were fed diet 1 during the first week of the trial and were then abruptly switched to diet 2 which was fed until slaughter. All cattle were implanted[1] on day 1 of the trial. Initial and final weights for all cattle were obtained by averaging the weights of the cattle taken on two successive days. Intermediate weights were taken every 28 days. At the same time initial weights were taken, the steers were measured for hip height and corresponding frame scores were assigned using the Eller classification system (1979).

Rib fat thickness measurements were taken initially and every 28 days therafter with a Cook's Probe. As each individual steer approached 10.2 mm rib fat thickness, rib fat was measured weekly. Each steer was slaughtered at an estimated 10.2 mm rib fat thickness. At slaughter, steers were weighed and then hauled 8.1 km to a privately owned packing house. Warm carcass weights and dressing percentages were recorded. Following a 48 h chill at 2 C, the right side of each carcass was ribbed between the 12th and 13th ribs.
Thirty minutes after ribbing the carcass was scored for marbling so that appropriate USDA quality grades could be assigned (USDA, 1978). Rib fat thickness and rib eye size were also measured. Percent kidney, heart, and pelvic fat was estimated for yield grade determination. The right side 9-10-11th rib sections and the right side 12th rib sections were individually wrapped in 3 layers of polyethylene, frozen at − 18 C for a minimum of 30 days, and retained for later analysis.

Right side 12th rib sections were retained for Warner-Bratzler (W-B) shear force tests. Steaks 2.5 cm thick were cut from the 12th rib section and thawed at 4 C for 24 h. Steaks were then broiled on a Farber-Ware Open-Hearth broiler to an internal temperature of 70 C (Cross et al., 1978). Steaks for W-B shear were cooled for 12 h to 20 C and four cores, 2.5 cm in diameter, were taken. Each core was sheared twice and the values were averaged. Cooking loss was calculated as the percent weight loss between the initial frozen steak and the final cooked steak after 12 h cooling at 20 C.

The 9-10-11th rib sections were thawed for 48 h at 4 C and separated into soft tissue and bone. Soft tissue samples were ground three times, thoroughtly mixed, and subsampled in duplicate. Subsamples were chemically analyzed for fat, protein, and water (AOAC, 1975). Carcass chemical composition was estimated from 9-10-11th rib composition using prediction equations derived by Hankins and Howe (1946).

Two calves of each biological type were selected at random for slaughter on day 1 of the trial. The dressing percentages and initial carcass compositions of these calves were used to estimate initial carcass weights and compositions of each biological steer type.

Least squares analysis (Neter and Wasserman, 1978) was calculated for an incomplete block design. Pens served as blocks, cattle types served as treatments, and individual steers were replicates. Pearson product-moment correlations measuring the strength of relationship between two varibles (Nie et al. 1975) were calculated between days on feed postweaning and feed to gain (F:G) ratios, feed to lean carcass weight gain ratios and feed to unit change in rib fat ratios.

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[1] Compudose®, Eli Lilly and Co., Indianapolis, IN

RESULTS AND DISCUSSION

The mean age across cattle type was 217 ± 4 d. Initial weight did differ ($P<.05$) between all 3 steer types, as shown in table 3 with CC steers being heaviest and HOL steers lightest. The CC and HOL steers had an initial frame score of 6.9 and 8.1, respectively, which is representative of large frame, late maturing cattle (Eller, 1979). The AC steers had a smaller ($P<.05$) initial frame score of 4.2 which is typical of medium frame cattle with a moderate growth curve. Initial rib fat estimates were also different ($P<.05$) between the three steer types with the AC steers being the fattest. The initial AC steers also contained 3.2 percent more carcass fat than the initial CC steers. Cianzio et al. (1982) also observed carcasses of smaller steers to contain approximately 3% more fat than did those of the larger steers. This difference in carcass fat content was maintained throughout the trial. While both the AC and CC steers increased in carcass fat content, the AC steers contained approximately 3% more carcass fat at slaughter (table 5). While the final carcass fat content was higher ($P<.05$) for AC steers than CC steers, the final rib fat measurements were not different ($P<.05$). This data suggests that AC steers had a higher initial percentage of subcutaneous fat that remained more constant during the finishing period. Therefore, the increased contribution of subcutaneous fat to total fat in the CC steers could reflect differences in time of onset of fatterning between the two cattle types. Cianzio et al. (1982) observed similar changes between small frame cattle and large frame cattle. The data of these two studies suggest that large frame cattle which should include the CC steers of this study fatten at a later age.

As shown in table 6, AC steers reached an estimated 10.2 mm rib fat thickness after 74 days on feed, but the CC steers required a significantly longer 127 d. Though this trial was designed for all steers, regardless of cattle type, to be slaughtered at 10.2 mm rib fat, the HOL steers after reaching 417 d of age still had not reached this fat end point. Since at 417 d of age the live weights of the HOL steers were not different ($P<.05$) from the live slaughter weights of the CC steers (table 5) and since there were no differences ($P<.05$) in the initial frame score measurements between the CC and HOL steers, the decision was made to slaughter the HOL steers.

While the AC steers reached the terminal rib fat thickness in fewer days ($P<.05$) and at lighter weights ($P<.05$) than the CC steers, the AC and CC steers had similar quality grades. Because of the young age at slaughter and narrow range in age of the steers in this study, we were unable to determine the age or weight at which marbling deposition occurs between these two cattle types.

W-B shear values and cooking loss percentages were similar ($P<.05$) between all cattle types (table 5). The W-B shear values were particularly low reflecting the tenderness of the meat and the young ages at which these steers were slaughtered. Millward and Waterlow (1978) observed protein synthesis rate to be elevated during rapid growth of laboratory animals and this may be true for cattle as well. Under these conditions, newly synthesized collagen should represent a greater proportion of the total muscle collagen. Newly synthesized collagen contains fewer intermolecular cross-links, resulting in less stable collagen fibers with higher soluability (McClain, 1976). Hill (1966) showed that high collagen solubility contributes to increased meat tenderness.

As shown in table 5, final carcass protein content did not differ ($P<.05$) between cattle types. HOL steers had more ($P<.05$) final bone than either AC or CC steers.

Final carcass fat content was different (P<.05) for all 3 breeds with AC steers being the fattest and HOL steers the leanest. Consequently, lean carcass weights differed (P<.05) between cattle types with CC steers having the greatest lean carcass weight and AC steers the least lean carcass weight. Differences in lean carcass weights between cattle types are most likely a reflection of the heavier live weights, correspondingly heavier carcass weights, and the lower carcass fat contents at slaughter of the CC steers and HOL steers compared to the AC steers.

No differences (P<.05) were observed in average daily gain during the finishing period or in weight per day of age at slaughter between the AC and CC steers (table 6). This data is similar to the observation of Cianzio et al. (1982) between small frame cattle and large frame cattle and may suggest that the differences in live weight at slaughter were determined at an earlier age (before 217 d). Similarly, Maino et al. (1981) observed postweaning average daily gain differences due to frame size to be small and insignificant when comparing cross bred cattle of frame scores 3, 4 and 5.

CC steers consumed significantly more feed per day during the finishing period than did AC steers. AC steers had higher (P<.05) daily feed intakes than did HOL steers. This data somewhat disagrees with the observation of Thonney et al. (1981) in which they observed Holstein steers to eat .76 kg per day more dry matter than Angus steers. This difference might be accounted for in that Thonney et al. compared Holstein steers to small frame Angus steers and this study compared Holstein steers to medium frame Angus steers.

AC steers required less feed (P<.05) per kilogram of live weight gain than did either CC steers or HOL steers (table 7). These data support the findings of Cundiff et al. (1981) where breed groups reaching the small degree of marbling in the fewest days and requiring the least NEm tended to be the most efficient. In this study steers were taken to a constant rib fat thickness rather than to a small degree of marbling, but AC steers required fewer days (P<.05) post-weaning to reach 10.2 mm rib fat thickness. Significant differences between all three cattle types were observed in feed consumed per kilogram of lean carcass weight gain with the AC steers consuming the least and the HOL steers consuming the most. Though no difference (P<.05) in feed consumed per unit change in rib fat was observed between AC steers and CC steers, both consumed less (P<.05) feed per unit change in rib fat than did HOL steers. Crickenberger et al. (1978) found that Holstein steers fed to the same chemical fatness as beef cattle were less energetically efficient than beef types and that Chianina crossbreds were less efficient than Angus. They suggested that as carcass fatness increased, energetic efficiency also increased. Ayala (1974) has shown that Holsteins have higher maintenance energy requirements per unit of metabolic weight than Angus steers. Since AC steers contained more (P<.05) carcass fat at slaughter than did CC steers and both AC steers and CC steers contained more (P<.05) carcass fat at slaughter than did HOL steers, this study would support those observations.

Correlation between rib fat probe and actual rib fat measurement (table 8) was highly significant (r = .77). The simple correlations between the fat probe measurement and carcass fat thickness was highly significant (r = .77). The finding supports that of Williams and Bailey (1984) who observed the correlation to be highly significant at r = .81.

Table 9 presents correlations between number of days on feed postweaning and feed to live weight gain ratio, feed to lean carcass weight gain ratio, and feed to unit change in rib fat ratio. Significant positive correlations were only observed between number of postweaning days on feed and feed to lean carcass weight gain ratio, suggesting that regardless of the relationship between body fat composition and energetic efficiency, the length of time on feed may be more closely related to feed efficiency. Therefore, it is important to know the number of days required for a specific weight gain or a specific rib fat thickness in order to determine economic efficiency and production profitability for feedlot cattle during a postweaning finishing period.

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Table 1. Composition and analysis of the diets[a][b].

Item	Amount
Diet 1	
Ingredient	
Corn (IFN 4-02-935), %	54.4
Alfalfa hay (IFN 1-00-068), %	25.3
Soybean meal (IFN 5-04-600), %	20.3
Analysis	
Dry matter, %	88.9
Crude protein, %	16.1
Calcium, %	.70
Phosphorus, %	.36
Metabolizable energy Mcal/kg	2.87
Diet 2	
Ingredient	
Corn (IFN 4-02-935), %	69.5
Corn cobs (IFN 1-02-782), %	10.2
Soybean meal (IFN 5-04-600), %	20.3
Analysis	
Dry matter, %	88.6
Crude protein, %	14.1
Calcium, %	.09
Phosphorus, %	.34
Metabolizable energy Mcal/kg	3.00

[a] Expressed on a dry matter basis.

[b] In addition to each diet a mineral mixture consisting of equal parts limestone (IFN 6-02-632) and a commercial mineral supplement containing 19% calcium and 18% phosphorus was provided free choice.

Table 2. Experimental design[2].

Cattle type	Pen 1	Pen 2	Pen 3
	Number of Steers		
Chianina cross	5	5	
Angus cross	5	5	5
Holstein	5	5	5
Total	15	15	10

[a] In addition, two steers of each biological type were slaughtered on day 1 of the trial.

Table 3. Starting weights, ages, frame scores and rib fat probes.

Cattle type	Weight, kg	Age, d	Frame score	Rib fat probe, mm
Chianina cross	336^{a}	227	6.9^{a}	4.8^{a}
Angus cross	308^{b}	222	4.2^{b}	6.9^{b}
Holstein	242^{c}	206	8.1^{a}	1.5^{c}
Mean	290	217	6.5	4.1
SE	9.1	4.0	.4	.4

^{a,b,c}Means within a column with a different superscrip differ (P<.05).

Table 4. Carcass composition of initial slaughter steers.

	Rib fat		Dressing percentage		Moisture	
Cattle type	mm	SD	%	SD	%	SD
Chianina cross	4.50	.10	57.3	.75	66.1	.75
Angus cross	6.25	.20	54.3	.04	66.5	3.30
Holstein	1.25	.16	46.2	1.10	68.2	2.75

	Protein		Bone		Fat		Lean carcass weight	
	%	SD	%	SD	%	SD	kg	SD
Chianina cross	19.7	60	17.0	3.3	9.4	.7	126.5	14.3
Angus cross	18.9	.40	14.0	.4	12.6	.5	95.5	17.4
Holstein cross	19.2	.05	23.8	3.5	5.5	.1	53.1	4.8

Table 5. Final carcass composition.

Cattle type	Final weight, kg	Carcass weight, kg	#1 Ribeye area, cm^2	Rib fat, mm	Kidney, heart, pelvic fat, %	Quality^d Grade	Yield Grade
Chianina Cross	489^a	312^a	95.5^a	9.4^a	2.7	11.6^a	2.0^a
Angus Cross	405^b	242^b	62.9^b	9.9^a	2.5	11.6^a	2.4^b
Holstein	456^a	258^c	63.2^c	4.6^b	2.6	9.8^b	2.6^b
Mean	445	266	74.8	7.9	2.6	11.0	2.4
SE	7.65	5.56	2.51	.54	.10	.22	.09

	Bone %	Fat %	Protein %	Lean Carcass Weight kg	W-B Shear kg	Cooking loss %
Chianina Cross	11.58^a	19.22^a	20.4	219.1^a	2.1	33.0
Angus Cross	13.90^a	22.07^b	20.5	154.6^b	1.9	35.5
Holstein	16.54^b	16.72^c	21.0	165.2^c	2.0	32.7
Mean	$14.30	18.82	20.7	174.6	2.0	33.8
SE	.94	.46	.27	4.7	.1	.1

[a,b,c] Means within a column with a different superscript differ ($P<.05$).

[d] Quality grade: low Good = 9, average Good = 10, high Good = 11, low Choice = 12.

Table 6. Performance of different steer types.

Cattle Type	Slaughter age d	Days Fed	ADG[e] kg	WDA[f] kg	ADF[g] kg	Change in rib fat mm	LWG[h] $kg \cdot d^{-1}$
Chianina Cross	354^{bc}	127^{bc}	1.21^{b}	1.39^{b}	10.26^{bc}	4.6^{bc}	$.61^{b}$
Angus Cross	296^{ac}	74^{ac}	1.31^{a}	1.37^{a}	9.20^{ac}	3.0^{c}	$.66^{a}$
Holstein	417^{ab}	211^{ab}	1.00^{ab}	1.10^{ab}	7.97^{ab}	3.1^{b}	$.43^{ab}$
Mean	356	139	1.17	1.27	9.00	3.4	.56
SE	8.9	10.0	.04	.03	.23	.03	.02

[a,b,c] Means within a column with a different superscript differ ($P<.05$).

[e] Average daily gain (ADG).

[f] Weight per day of age (WDA).

[g] Average daily feed intake (ADF).

[h] Lean carcass weight gain (LWG).

Table 7. Feed efficiency of different steer types.

Cattle Type	Feed to live weight gain kg/kg	Feed to lean carcass weight gain kg/kg	Feed to unit change in rib fat kg/mm
Chianina Cross	8.73^{a}	16.41^{a}	282.8^{a}
Angus Cross	7.19^{b}	14.31^{b}	227.0^{a}
Holstein	8.24^{a}	18.82^{c}	538.0^{b}
Mean	7.97	16.70	357.6
SE	.23	.47	24.5

[a,b,c] Means within a column with different superscripts differ ($P<.05$).

Table 8. Correlations of rib fat probes and actual rib fat measurements.

Cattle Type	Initial probe mm	Actual measurement mm	Final probe mm	Actual measurement mm	Correlation (r)
Chianina Cross	4.8	4.8	9.4	9.4	.61**
Angus Cross	6.8	6.9	10.0	9.9	.68**
Holstein	1.3	1.5	4.6	4.6	.78**
Mean			7.9	7.9	.77**
SE			.53	.54	

**P<.01

Table 9. Simple correlations (r) between days on feed and F:G ratio, feed to lean carcass weight gain ratio, and feed to unit change in rib fat ratio.

Cattle Type	F:G ratio	Feed to Lean Carcass Weight Gain Ratio	Feed to Unit Change to Rib Fat Ratio
Chianina Cross	— .39	.58	.56
Angus Cross	.05	.72**	.38
Holstein	— .60	.77**	.12
Mean	.15	.97**	.07

**P<.01

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