ESTIMATES OF GENETIC AND PHENOTYPIC PARAMETERS FOR CARCASS AND MEAT TRAITS OF BEEF CATTLE [1]

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Summary

Data from nine parental breeds and three composite populations described in the preceding article were used to calculate heritabilities and phenotypic and genotypic correlations among carcass and meat traits. Phenotypic correlations indicated that marbling was a poor predictor of longissimus muscle palatability attributes of the individual carcasses. Heritability estimates were intermediate to high for fatness measures but generally low for palatability attributes. The high negative genetic correlation (-.56) between percentage of retail product and marbling score and the relatively low genetic correlations between percentage of retail product and palatability attributes suggest simultaneous selection for percentage of retail product and palatability, rather than for marbling score. Correlations among breed group means were generally high between measures of fatness and palatability attributes and were high and negative between percentage of retail product and marbling score or other fatness measures. Thus, opportunity is limited to select among breeds for high levels of marbling and a high percentage of retail product at the same time. The most logical approach to resolving that genetic antagonism is to form composites from breeds that contribute an optimum balance between favorable carcass composition and desirable meat palatability.

(Key Words: Carcass, Meat Palatability, Heritabilities, Genetic Correlations.)

Introduction

Although interest in carcass and meat traits has increased dramatically in recent years, data on genetic relationships and heritabilities of carcass traits are limited. Our objective in this study was to estimate phenotypic and genetic (co)variation for carcass and meat traits of beef cattle.

Experimental Procedures

Breeds and matings used to establish the three composite populations, as well as specifics of feeding, management, slaughter, carcass data collection, carcass fabrication and longissimus palatability traits were described in the preceding article.

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[1]This article was derived from a research paper accepted for publication in the Journal of Animal Science. These data are from the Germ Plasm Utilization project that was conducted under the leadership of Dr. Keith E. Gregory at the USDA, ARS, Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, NE. Michael E. Dikeman is a collaborator on the carcass retail product data collection.

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Results and Discussion

Differences among breed groups were statistically significant for all traits analyzed. Breed group means were presented in the preceding article.

Estimates of genetic correlations (rg's), phenotypic correlations (rp's), and heritabilities (h^2) for carcass and meat traits are presented in Table 1. The heritability estimate for 12th rib adjusted fat thickness was moderate (h^2=.30). Twelfth rib adjusted fat thickness accounted for considerable variation in percentage of retail product trimmed free of surface fat (rp=-.56, R^2=.31), but accounted for little variation in marbling score (rp=.24, R^2=.06). The heritability estimate for marbling was high (h^2=.52). Variation in marbling score accounted for little of the variation in longissimus shear force (R^2=.05) and sensory panel evaluations of tenderness (R^2=.03), juiciness (R^2=.04), or flavor (R^2=.01). These cattle were slaughtered at an average age of 437 days, following semi-accelerated feeding. Marbling had a very low predictive value for longissimus palatability of individual carcasses. The relationships of longissimus fat percentage with retail product and longissimus palatability were similar to those of marbling. The heritability estimates for longissimus shear force (h^2=.12) and sensory panel tenderness (h^2=.21), juiciness (h^2=.24), and flavor (h^2=.06) were relatively low, but that for percent retail product was high (h^2=.50).

Generally, estimates of genetic correlations were much higher than estimates of phenotypic correlations. Even though marbling was a poor predictor of longissimus palatability of individual carcasses, the high rg's of marbling and longissimus fat with shear force (rg's = -1.00 and -.93, respectively) and the high rg (.96) between marbling and longissimus fat suggest that marbling may be an indirect selection criterion to reduce shear force.

The relatively high negative rg of marbling with percentage of retail product (-.56) reveals the high genetic antagonism between these two traits. However, the rg's of retail product percentage with longissimus shear force and sensory panel evaluations of palatability were low.

Correlations among breed group means for carcass and meat traits are presented in Table 2. Marbling score and percentage of longissimus fat were highly correlated with shear force (-.80 and -.74) and with sensory panel scores for tenderness and juiciness (range from .65 to .92). The correlation of marbling score with sensory panel flavor was .61. The correlation between marbling score and longissimus fat was .99.

These values reflect high correlations among breed group means for both marbling score and percentage of longissimus fat at the 12th rib and palatability attributes. However, high correlations also were observed among breed group means for marbling score and longissimus fat percentage with other measures of fat, e.g., 12th rib adjusted fat (.81 and .82). The correlations of marbling score and longissimus fat percentage with percentage of retail product (free of fat) were - .94 and -.95. Retail product percentage was generally negatively associated with palatability attributes, suggesting limited opportunity to select among breeds to achieve high levels of marbling simultaneously with a high percent retail product in the carcass

The optimum way to resolve the generally high genetic antagonism between retail product percentage and meat palatability may be to form composites from breeds that contribute an optimum balance between favorable carcass composition and desirable meat palatability. Further, desirable carcass and meat traits should be balanced with production traits needed to achieve high production efficiency in a given production environment.

Table 1. Genetic and Phenotypic Parameters among Carcass and Meat Traits of Cattle[a,b,c]

Trait	Adj. Fat Th. (inch)	Marbling Score	Longissimus Muscle Fat (%)	Shear Force (lb)
Adj. fat th. (inch)	.30 ± .09	.24	.26	-.06
Marbling score	.32 ± .16	.52 ± .10	.63	-.23
Longissimus muscle fat (%)	.28 ± .17	.96 ± .06	.47 ± .09	-.23
Shear force (lb)	-.35 ± .34	-1.00 ± .45	-.93 ± .44	.12 ± .08
Tenderness	.30 ± .25	.34 ± .19	.34 ± .20	-.98 ± .74
Juiciness	.45 ± .23	.28 ± .18	.41 ± .18	-.96 ± .53
Flavor	.31 ± .45	.34 ± .38	.48 ± .43	-1.00 ± 1.00
Retail product (%) 0 in fat trim	-.76 ± .28	-.56 ± .19	-.55 ± .20	.22 ± .26

[a]Heritabilities (h^2) on diagonal (underlined).
[b]Genetic correlations (rg's) below diagonal.
[c]Phenotypic correlations (rp's) above diagonal.

Table 2. Genetic and Phenotypic Parameters among Carcass and Meat Traits of Cattle[a,b,c]

Trait	Sensory Panel			Retail Product (%) 0 in Fat Trim
	Tenderness	Juiciness	Flavor	
Adj. fat th. (inch)	.05	.10	.10	-.56
Marbling score	.19	.20	.12	-.42
Longissimus muscle fat (%)	.16	.20	.12	-.47
Shear force (lb)	-.57	-.19	-.23	.15
Tenderness	.21 ± .08	.60	.16	-.11
Juiciness	.91 ± .14	.24 ± .08	-.06	-.14
Flavor	.81 ± .60	1.00 ± .86	.06 ± .08	-.14
Retail product (%) 0 inch fat trim	-.14 ± .22	-.31 ± .21	.02 ± .38	.50 ± .10

[a]Heritabilities (h^2) on diagonal (underlined).
[b]Genetic correlations (rg's) below diagonal.
[c]Phenotypic correlations (rp's) above diagonal.

Table 3. Correlation Coefficients among Breed Group Means for Carcass and Meat Traits

Trait	Shear Force (lb)	Sensory Panel Tenderness	Sensory Panel Juiciness	Sensory Panel Flavor	Adj. Fat Th. (inch)	Marbling score	Longissimus Muscle Fat (%)
Shear force (lb)							
Sensory Panel							
Tenderness	-.95**						
Juiciness	-.82**	.79**					
Flavor	-.86**	.75**	.55				
Adj. fat th. (inch)	-.49	.54	.82**	.17			
Marbling score	-.80**	.72**	.92**	.61*	.81**		
Longissimus muscle fat (%)	-.74**	.65*	.92**	.55	.82**	.99**	
Retail product .0 inch fat trim (%)	.62*	-.55	-.87**	-.37	-.91**	-.94**	-.95**

*P<.05. **P<.01.

The cattle Germ Plasm Utilization (GPU) research program began with the 1978 breeding season. The primary objective is to estimate the retention of combined individual and maternal heterosis in advanced generations of *'inter se'* mated 'composite' populations established with contributions from either four or five parental breeds. This research program is the largest, most comprehensive one of its kind.

Additional information on retained heterosis from composite populations for major bioeconomic traits can be obtained by writing to Dr. Keith E. Gregory, USDA, ARS, Roman L. Hruska U.S. Meat Animal Research Center, P.O. Box 166, Clay Center, Nebraska 68933.