Economic evaluations of beef bulls in an integrated supply chain[1]

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ABSTRACT: Economic benefits from the use of expected progeny of a sample of beef bulls with genetic evaluations were calculated over an integrated supply chain for combinations of price discounts for intramuscular fat and LM area. Fixed backfat finish and marketing at the point of optimized gross margins were considered. An economic model was used to calculate average expected gross margins for a sample of bulls. Across-breed, age-constant genetic evaluations were used to predict carcass characteristics of progeny including weight, retail yield, intramuscular fat, and LM area, as well as input requirements including feed and housing as a function of time on feed. Proportion of retail cuts affected by price discounts was included in the calculations. Optimizing endpoints did not affect rankings to any extent relative to a fixed end point in this sample of bulls, as a result of fixed endpoints being similar to optimized endpoints for the economic situation considered. However, rank correlations were only 0.63 and 0.71 between rankings for no discount being applied and rankings with discounts for intramuscular fat and LM area, for fixed and optimized endpoints, respectively. We conclude that market prices are necessary considerations in choices of bulls to use in commercial beef production.

Key words: beef production, bioeconomic model, genetic evaluation, sire ranking

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INTRODUCTION

Evolution of beef supply chains in North America has resulted in complex and multifaceted economic enterprises. Breeding selection decisions may be suboptimal on a chain-wide basis if there are incomplete links between supply chain members or if consumers' valuation of retail product is incomplete. By applying benefits of breeding decisions to the entire supply chain, members can determine what action breeders should take when faced with further integration and to reflect consumers' valuation of beef products. Integrated bioeconomic models of beef production have been developed to compare beef cattle genotypes at several slaughter endpoints (Amer et al., 1994; Williams and Bennett, 1995). These studies evaluated several genotypic profiles of cattle based on breed characteristics but did not consider genotypic differences within breeds.

In an integrated supply chain, slaughter end point can be set at a constant fatness, weight, age, or when gross margin is maximized. Cattle are often slaughtered in commercial production at a point where the individual or group is deemed to offer the most profit to the producer, as determined by visual estimation of degree of subcutaneous fatness within an acceptable range of BW. On the other hand, estimated genetic differences of progeny of bulls are usually based on measurements and evaluations on an age-constant basis, often at or around 1 year of age. Age-constant genetic evaluations for individual bulls have been used as parameters in a bioeconomic model to rank bulls for net economic value in a specified production system with specified endpoints (Wilton et al., 2002), with significant reranking found for different production levels of mates. More accurate evaluations might be obtained through optimization of endpoints and through more detailed consideration of retail product valuations such as size of retail cuts.

The objective of this study was to compare rankings of beef bulls based on predictions of carcass characteristics and input requirements of expected progeny using age-constant genetic evaluations in a bioeconomic model of chain-wide economic benefits at specified or

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optimized endpoints and at several different combinations of values of fatness and LM area.

MATERIALS AND METHODS

Animal Care and Use Committee approval was not obtained for this study because the data were obtained from an existing database.

Genetic Evaluation and Animal Data

Genetic evaluation data were acquired from Beef Improvement Ontario's Bull Evaluation Program on a group of bulls born at the Elora Beef Research Center and New Liskeard Agricultural Research Center in Ontario, Canada. Bulls (n = 48) by Angus (n = 22), Hereford (n = 4), Simmental (n = 9), Gelbvieh (n = 8), or crossbred (n = 5) sires bred to crossbred dams (average breed composition 40% British breeds, 57% Continental breeds, 3% dairy breeds) were born in the spring of 2002. These bulls were part of an ongoing beef cattle genetics research program conducted by the University of Guelph and were raised at the University of Guelph's Elora Beef Research Center from weaning until slaughter in the spring of 2003.

Genetic evaluations for bulls were calculated using BLUP methods, and expressed as across-breed EPD, as described by Sullivan et al. (1999). Traits evaluated included birth weight (**BrW**); weaning gain (**WG**), defined as total weight gain from 0 to 200 d of age; postweaning gain (**PWG**), defined as total weight gain from 200 to 365 d of age; intramuscular fat percentage (**IMF**), based on ultrasound measurements at 365 d of age between the 12th and 13th ribs within the LM; LM area (rib-eye, **REA**), based on ultrasound at 365 d of age of the REA measured between the 12th and 13th ribs; backfat (**BF**), based on ultrasound BF depth measured between the 12th and 13th ribs at 365 d of age; and maternal WG (**MILK**), defined as the expected average progeny weight gain difference attributable to milk consumption from 0 to 200 d of age. Comparisons of genetic evaluations with those in the population of bulls tested in Ontario in 2003 (C. J. B. Devitt, Center for Genetic Improvement of Livestock, Guelph, Ontario, Canada, personal communication) are given in Table 1. Mates were assumed to be at the median level of performance as given in Table 1.

Bioeconomic Model

The bioeconomic model used to predict progeny performance and gross margins consisted of a series of equations to model an integrated beef supply chain (Figure 1). The supply chain was assumed to operate from the cow-calf level of production through to retail sales of progeny carcasses. End point was defined as the level of a given trait that signaled the end of production for an individual animal. In this example, BF was the trait to which the end point was applied. Various other traits could also have been suitable as endpoints, such as REA, IMF level, or finished weight. The end point could be fixed by the user or could be variable. Individual cow herd (rearing unit), feedlot (growing unit), processor (processing unit), and retail (retailing unit) level data were utilized to calculate gross margins for the integrated beef supply chain and, for variable endpoints, select the end point that maximized gross margins.

Once the end point was determined, age of the average progeny required to reach that end point was determined using genetic and producer level data, as described in the following section. Phenotypic levels for output and input traits were then determined based on this age, again utilizing genetic and producer level data. In allowing the end point to vary, the objective was to maximize gross margin. In this example, level of BF was allowed to vary to a point at which chain-wide gross margin was maximized and any marginal increase or decrease in BF decreased the chain-wide gross margin.

Phenotypic levels for REA, BF, and IMF traits were used in determining expected yield results for processors and retailers. Information on phenotypic levels for traits and yields were then used to calculate revenues and costs for the entire chain. Retailing level revenues were adjusted where appropriate for quality factors: in this study, level of IMF and area of LM as a measure of size of retail cut. Adjusted retail revenues and costs were then combined to determine chain-wide progeny gross margin. Bulls were ranked according to chain-wide gross margin resulting from using their expected progeny within the supply chain. Gross margins were reported on an aggregate basis for the entire chain, avoiding the complications of transfer pricing within a nonintegrated chain. Detailed descriptions of the model, prediction equations, prices, and costs are given in Van Groningen et al. (2005).

Prediction of Progeny Phenotype to Variable Slaughter Endpoints

An important consideration for the prediction of chain-wide gross margin is accurate prediction of the progeny phenotype from management and genetic information. In this study, management and feeding programs were considered fixed to focus on genetic differences. Progeny values were calculated on the basis of bulls being used on mates of the population average genetic merit.

In this model, 2 methods for determining the BF target end point (***tbf***) were used. With the first method, 7 mm of BF was assumed to be the end point. Seven millimeters of BF was chosen because this level is considered an adequate end point to finish in currently available bull ranking models available from Beef Improvement Ontario. The second method for selecting the end point in this model was to select the end point such that its value maximized gross margin.

Progeny phenotypes at varying levels of different endpoints from age-constant, across-breed EPD were pre-

Table 1. Comparison of sire group, across-breed EPD to those of the Ontario population

Population		BrW[1]	WG[2]	PWG[3]	BF[4]	REA[5]	IMF[6]
Group of 48 sires evaluated	Mean	–1.0	17.6	15.0	0.20	–0.4	0.14
	SD	1.6	4.2	5.6	0.29	1.5	0.15
	Max	2.2	27.3	25.2	1.06	2.6	0.63
	Min	–4.2	5.1	0.8	–0.38	–4.8	–0.15
Ontario population	Median[7]	0.1	14.3	10.4	–0.27	0.8	–0.06
	SD[8]	0.6	2.0	2.0	0.36	1.3	0.14
	Max[9]	3.6	24.5	21.9	1.70	6.6	0.71
	Min[10]	–3.4	1.7	–2.7	–1.13	–5.4	–0.46

[1] Birth weight across breed, kg.
[2] Weaning gain across breed, kg.
[3] Postweaning gain across breed, kg.
[4] Backfat across breed, mm.
[5] LM area across breed, cm^2.
[6] Intramuscular fat across breed, %.
[7] 50th percentile value.
[8] 67th percentile value minus 50th percentile value.
[9] 99th percentile value.
[10] First percentile value.

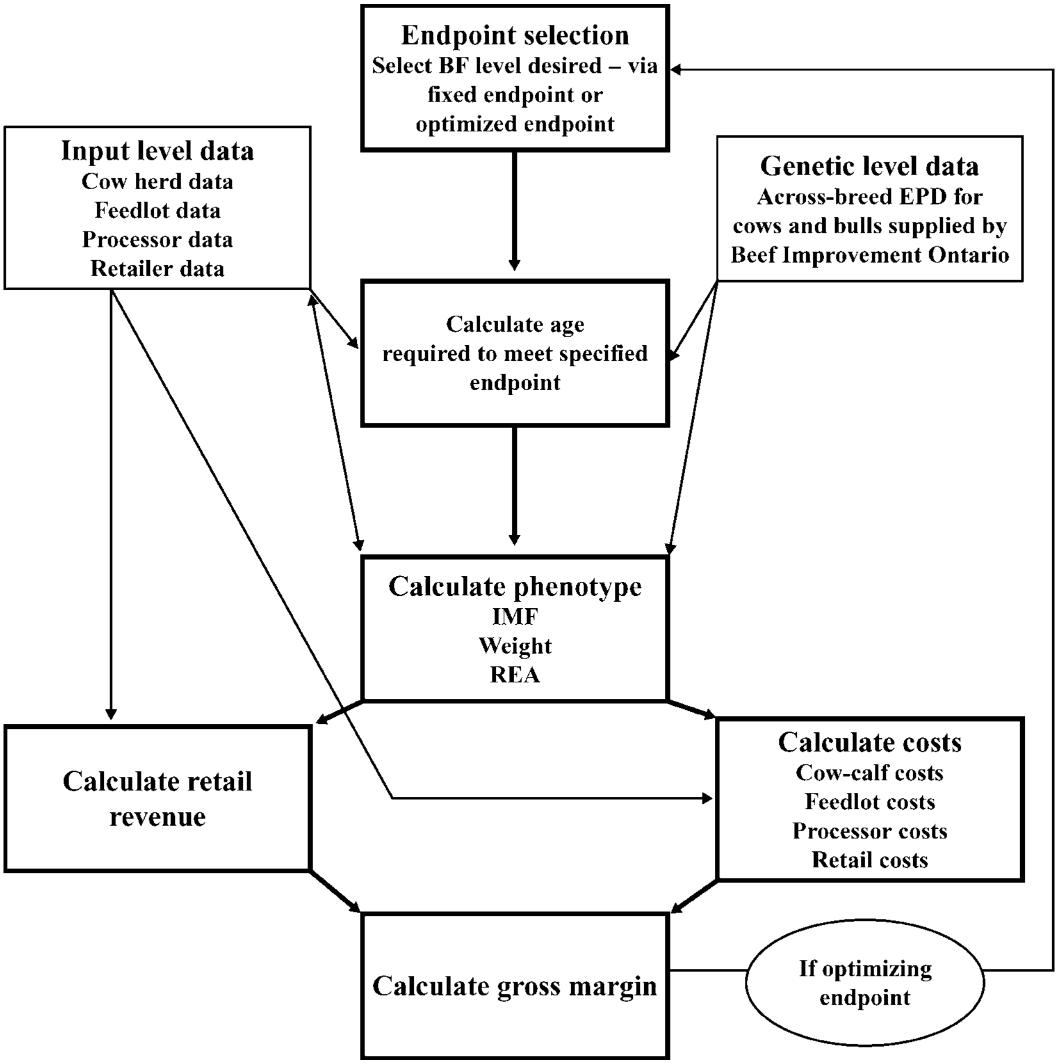

Figure 1. Flow chart of bioeconomic model using backfat (BF) as the end point criterion. IMF = intramuscular fat percentage; REA = LM area. Bold arrows signify the central flow of decision making in the diagram.

dicted. For purposes of illustration, the model description is based on a BF end point. After the end point trait and level were selected (by optimization or by selecting a fixed level), age required to meet that end point ($\boldsymbol{doa_{bf}}$) was calculated based on a predictive equation adapted from Brethour (2000). Predicted age required to meet the target end point for BF (doa_{bf}) was

$$doa_{tbf} = 365 + \frac{[\ln tbf - \ln(avgbf + bf_{bull} + bf_{cow})]}{(0.01065 + (bf_{bull} + bf_{cow})/365)},$$

in which tbf is target BF, $avgbf$ is average BF at 365 d of age from the growing unit, and bf_{bull} and bf_{cow} are bull and mate across-breed EPD for BF, respectively. Based on the age required to meet the end point, the remaining predicted phenotypic levels were calculated, (i.e., weight of progeny, LM IMF of progeny, and REA of progeny when target BF would be attained).

To determine weight of progeny when target BF would be attained (w_{tbf}), BrW (w_0) of progeny was calculated as $w_0 = avgBrW + BrW_{bull} + BrW_{cow}$, where $avgBrW$ is the rearing unit's average BrW, BrW_{bull} is the bull's across-breed EPD for BrW, and BrW_{cow} is the mate's across-breed EPD for BrW. Weight at weaning of progeny (w_{200}), was calculated as

$$w_{200} = w_0 + (avgwg + wg_{bull} + wg_{cow} + 2 \cdot milk_{cow}),$$

where $avgwg$ is the rearing unit average total gain from birth to weaning, wg_{bull} is the bull's across-breed EPD for WG from 0 to 200 d, wg_{cow} is the mate's across-breed EPD for WG, and $milk_{cow}$ is the mate's across-breed EPD for milk gain.

Total gain from weaning to slaughter ($\boldsymbol{gain_{tbf}}$) was calculated as follows:

$$gain_{tbf} = \left[avgpwadg + \left(\frac{pwg_{bull} + pwg_{cow}}{165}\right)\right] \times (doa_{tbf} - 200),$$

where $avgpwadg$ is the average daily gain of animals in the feeding unit, pwg_{bull} is the bull's PWG across-breed EPD, and pwg_{cow} is the mate's PWG across-breed EPD. Final weight at slaughter ($\boldsymbol{w_{tbff}}$) was calculated by adding PWG to weaning weight.

Average progeny phenotype for IMF at target BF ($\boldsymbol{imf_{tbf}}$) was found by combining age at target end point with deposition rate:

$$imf_{tbf} = doa_{tbf} \times \left(\frac{avgimf + imf_{bull} + imf_{cow}}{365}\right),$$

where $avgimf$ is the average IMF at 365 d of age in the feeding unit, imf_{bull} is the bull's IMF across-breed EPD, and imf_{cow} is the mate's across-breed EPD for IMF. Rate of IMF deposition was assumed to be linear over the lifetime of the animal for the purposes of this model.

Average phenotypic level of REA of progeny when target BF was attained ($\boldsymbol{rea_{tbf}}$) was calculated as

$$rea_{tbf} = doa_{tbf} \times \left(\frac{avgrea + rea_{bull} + rea_{cow}}{365}\right),$$

where $avgrea$ is the average REA at 365 d of age in the feeding unit, rea_{bull} is the bull's REA across-breed EPD, and rea_{cow} is the mate's across-breed EPD for REA. The rate of REA deposition was also assumed to be linear over the lifetime of the animal for the purposes of this model.

Estimation of Product Value

Total product value was calculated from total retail valuation of carcass components, including retail cuts, fat trim, and lean trim. Carcass weight was predicted by multiplying average progeny live weight at the end point by 60%, which was the assumed average dressing percent.

Retail yield was calculated as a prediction of saleable meat, as a percentage of the whole carcass. Cutability prediction equations from Shackelford et al. (1995) were used to predict product yields, fat trim, and bone yield because these equations used information that could be predicted easily based on the supply chain data and genetic information.

Value of retail product was derived from the total value of subprimal revenue. In this study, retail yields of 90% of the Canadian subprimal yields reported by the George Morris Center in the Canadian Boxed Beef Report (January 5, 2004) were used to account for lean and fat trimming resulting from converting subprimals to retail cuts. Retail products, their respective proportion of total product weight, and their respective prices are given in Table 2.

Potential effects of price differentials for varying levels of IMF and REA were examined by application of discounts to subprimals affected by these varying levels (Table 2). Both IMF level and muscle area discounts were primarily associated with prices of steaks. Approximately 43 and 31% of total retail products were affected by discounts for IMF and muscle area, respectively.

Five classes were used for IMF based on cutoffs for Canadian marbling score classes. The classes were AAA+, AAA, AA, A, and B (greater than 8%, 8.00 to 5.04%, 5.04 to 3.83%, 3.83 to 2.76%, and less than 2.76% IMF, respectively). The REA was used as an indicator of size of cut. The REA classes were dispersed 22.6 cm^2 from each other from a base of 100 cm^2, the classes 1 to 5 being greater than 145.2, 145.2 to 122.6, 122.6 to 100, 100 to 77.4, and less than 77.4 cm^2, respectively.

Four combinations of IMF and REA group valuation were used to portray different marketplace constraints on retail beef cuts meant to simulate the consumers' valuation, as affected by IMF and REA. Treatment 1 included no discounts to retail product of any kind, treatment 2 included discounts to retail product for IMF effect, treatment 3 included discounts to REA effect, and treatment 4 included discounts to both IMF and

Table 2. Boneless retail product percentages and prices with influences of IMF and REA on prices

Retail product	Percentage of total product	Price,[1] \$/kg	Discount proportion IMF	Discount proportion REA
Steak				
Tenderloin	1.4	33.00	1.00	0.50
Ribeye	3.0	23.10	1.00	1.00
New York strip	2.8	23.10	1.00	1.00
Top butt	2.9	13.20	0.80	0.50
Flank	0.4	9.70	0	0
Roast				
Eye of round	1.6	8.80	0.10	0
Inside hip	5.1	7.90	0.15	0
Outside round	3.3	7.90	0.25	0
Sirloin tip	2.6	7.90	0.25	0
Cross rib	4.8	7.70	0.15	0
Brisket	2.3	7.10	0.15	0
Blade	5.2	6.60	0.15	0
Lean ground	29.4	5.10	0	0
Fat trim	15.2	0.00	0	0
Bone	20.0	0.00	0	0

[1] Canadian dollars.

REA effects. The combinations of discounts are shown in Table 3.

Predicted mean phenotypic levels for IMF and REA were used, along with variances of IMF and REA, to calculate the distribution of expected progeny into 5 groups for both traits. The expected progeny groupings allowed the model to deal with valuation of the various classes in the absence of a continuous pricing function for varying levels of the respective traits.

Estimation of Production Costs

Preweaning Costs. Total costs were calculated on a per progeny basis, assuming 1 progeny born to a dam per year. Dam feed cost was estimated from ADFI as a percentage of BW. Costs attributable to additional BrW of calves were included to account for costs of increased dystocia with larger calves. Additional costs associated with heavier progeny at weaning due to genetic differences in growth were calculated to account for additional feed intake of calves before weaning. Additional weaning weight of progeny attributable to dam's milk could be accounted for in the model through costs of additional maternal WG, but this study considered only terminal progeny. A fixed cost per cow was included to account for various yearly fixed costs associated with keeping a cow herd. In this study, average expected effects on dystocia and growth of progeny of bulls across sex of calf and age of cow in the herd were used.

Feeding Unit Cost. Feeding unit costs reflected the cost of feeding and keeping a steer from 200 d of age to the age at which the target end point (BF) was attained. Steer feed intake was calculated from a series of equations developed by Guiroy et al. (2001), which incorporates diet energy levels and individual animal retained energy, calculated from BW and tissue growth during the feeding period. Daily yardage and financing costs per head per day on feed were also included, as well as a fixed cost per head for health costs. Details of the calculations are given in Van Groningen et al. (2005). In this study, average expected effects on predicted feed intake were influenced by genetic differences in BF deposition and growth rates.

Processing and Retailing Costs. Processing, including rendering, costs were determined from industry overhead operating costs. Retailing costs were determined from industry average retail unit costs per kg of retail product. (C. Van Groningen, V G Packers Ltd., Simcoe, Ontario, Canada, personal communication). Retailing costs included interest on retail inventory, as well as marketing costs.

Total Costs. Total costs to produce and retail beef from 1 progeny ($\boldsymbol{C_{tot}}$) were calculated as

$$C_{tot} = C_{rear} + C_{feed} + C_{process} + C_{retail},$$

where C_{rear} represents the costs to weaning, C_{feed} represents feedlot costs from weaning to slaughter, $C_{process}$ represents processing costs, and C_{retail} represents retailing costs.

Gross Margin

Gross margin was calculated by subtracting the sum of production costs from the retail revenue for expected

Table 3. Discounts (proportion of retail price deducted) used in quality adjustments of retail product for IMF and REA classes

Treatment[1]	IMF class[2] AAA+	AAA	AA	A	B	REA class[3] 1	2	3	4	5
1	0	0	0	0	0	0	0	0	0	0
2	0	0.1	0.2	0.3	0.8	0	0	0	0	0
3	0	0	0	0	0	0.7	0.35	0.1	0	0
4	0	0.1	0.2	0.3	0.8	0.7	0.35	0.1	0	0

[1] 1 = no discounts; 2 = IMF discounts, only; 3 = LM discounts, only; 4 = discounts for both.

[2] AAA+ = >8%; AAA = 8.00 to 5.04%; AA = 5.04 to 3.83%; A = 3.83 to 2.76%; and B = <2.76%.

[3] 1 = >145.2 cm^2; 2 = 145.2 to 122.6 cm^2; 3 = 122.6 to 100 cm^2; 4 = 100 to 77.4 cm^2; and 5 = <77.4 cm^2.

Table 4. Predicted progeny phenotypes at fixed and optimized endpoints[1,2]

	Fixed end point	Optimized end point			
	Treatment	Treatment			
Variable	All	1	2	3	4
Final age, d	386.1 (5.83)	419.3 (11.3)	434.4 (12.1)	395.5 (9.5)	415 (11.2)
Final weight, kg	540.4 (13.5)	592.3 (21.2)	615.7 (22.7)	555 (18.4)	585.4 (21.2)
Final LM area, cm^2	98.1 (15.4)	106.5 (24.1)	110.3 (25.8)	100 (20.8)	105.2 (24.1)
Final BF, mm	7 (0)	10.4 (0.4)	12.4 (0.5)	7.8 (0.3)	9.9 (0.5)
ADFI, kg	8.7 (0.21)	9.1 (0.2)	9.4 (0.2)	8.8 (0.2)	9.1 (0.2)
Carcass weight, kg	324.2 (8.1)	355.4 (12.7)	369.4 (13.6)	333 (11.0)	351.3 (12.7)

[1] Treatment 1 included no discounts to retail product of any kind, treatment 2 included discounts to retail product for IMF effect, treatment 3 included discounts to REA effect, and treatment 4 included discounts to both IMF and REA effects.

[2] Values in parentheses are SD.

progeny resulting from matings of each bull to dams of median performance. Bulls were ranked on the basis of gross margin. Average gross margins for treatments were tested pairwise using a 2-sample *t*-test with unequal variances.

RESULTS

Fixed End Point Selection Results

Average progeny phenotypes for the 48 bulls evaluated in this example were higher for all variables for the optimized end point compared with the fixed end point (Table 4). Price discounts for insufficient marbling increased final BF and final weight. Discounts for REA led to phenotypes closer to those for the fixed end point of 7 mm BF. Simultaneous discounts (treatment 4) moderated the effect of discounts for marbling, reflecting the balance between fat deposition and size.

The fixed end point resulted in 2 groupings of gross margins (Table 5). The lower gross margin groupings involved treatments 2 and 4, which had IMF quality discounts, whereas the higher gross margin grouping, treatments 1 and 3, did not. Mean chain-wide gross margins within the fixed end point selection method were significantly different ($P < 0.01$) from one another.

Table 5. Predicted progeny revenue ($), cost of production ($), and gross margin ($) for fixed end point treatments[1]

Treatment	Variable	Mean	SD
1	Retail revenue index	1	0
	Retail revenue	1,932.25	56.09
	Cost of production	1,287.98	23.78
	Gross margin	644.27	33.05
2	Retail revenue index	0.86	0.01
	Retail revenue	1,653.33	41.55
	Cost of production	1,278.22	23.23
	Gross margin	375.11	20.78
3	Retail revenue index	0.99	0.004
	Retail revenue	1,909.08	50.76
	Cost of production	1,287.17	23.58
	Gross margin	621.91	28.3
4	Retail revenue index	0.84	0.011
	Retail revenue	1,630.16	35.85
	Cost of production	1,277.41	23.03
	Gross margin	352.75	16.08

[1] Canadian dollars.

Chain-wide gross margins per progeny were highest for treatment 1 (control) at $644 per progeny. The retail revenue index for the control reflects the fact that the entire retail product was valued at full retail price with no discounting for IMF or REA. In treatment 2, progeny revenues were indexed for IMF effects. The indexing involved both the discount levels in Table 3 and the portion of retail product on which IMF had an effect on retail valuation. Changes in gross margin were mainly due to direct discounting of prices.

In treatment 3, revenues were indexed (discounted) for REA quality effects. Portions of the retail product derived from progeny in treatment 3 were indexed for the effect that REA had on retail valuation. The retail revenue index was only reduced to 0.98 (Table 5) for this sample of sires with the discount ranges as shown in Table 3. Greater effects might be found for more heterogeneous populations, higher discounts, or more closely specified discount ranges.

Optimal End Point Selection Results

The optimal end point selection method returned similar patterns of results to that of the fixed end point selection method (Table 6). There were again 2 groupings of gross margins differentiated based on whether the indexing factor includes the IMF effect.

Optimized end point selection returned higher gross margins for each treatment compared with fixed end point (Table 6 compared with Table 5). The higher gross margins resulting from the optimal end point selection method were expected, as the fixed end point selection level was suboptimal in that gross margins could be increased by increasing the end point level.

The method of allowing the point at which progeny were deemed ready for processing to equal the point at which maximum progeny gross margin was attained, utilized in the optimum end point selection, delivers

Table 6. Predicted progeny revenue ($), cost of production ($), and gross margin ($) for optimized end point treatments[1]

Treatment	Variable	Mean	SD
1	Retail revenue index	1	0
	Retail revenue	2,061.96	77.34
	Cost of production	1,396.82	41.18
	Gross margin	665.14	37.48
2	Retail revenue index	0.88	0.008
	Retail revenue	1862.4	69.61
	Cost of production	1,439.64	44.29
	Gross margin	422.76	27.6
3	Retail revenue index	0.98	0.005
	Retail revenue	1,940.44	60.58
	Cost of production	1,316.93	34.43
	Gross margin	623.51	28.76
4	Retail revenue index	0.85	0.01
	Retail revenue	1,737.41	54.28
	Cost of production	1,371.28	40.19
	Gross margin	366.14	17.85

[1] Canadian dollars.

Table 7. Rank correlation between sire rankings for gross margins for combinations of fixed and optimal endpoints[1]

Treatment[2]	1	2	3	4
1	0.99	0.73	0.97	0.63
2	0.84	0.96	0.64	0.94
3	0.95	0.71	1.00	0.58
4	0.71	0.91	0.65	0.98

[1] Upper off-diagonal shows fixed end point; lower off-diagonal shows optimized end point.

[2] Treatment 1 included no discounts to retail product of any kind, treatment 2 included discounts to retail product for IMF effect, treatment 3 included discounts to REA effect, and treatment 4 included discounts to both IMF and REA effects.

different expected phenotypes for each treatment (as seen in Table 4), as well as different gross margins.

Changes in phenotypic levels shown in Table 4 for each treatment were directly due to the level of BF that progeny of each bull were allowed to attain and not changes in genetics. In optimum end point selection, progeny of individual bulls were allowed to reach the level of BF at which gross margins were maximized. The varying levels of BF led to varying ages and therefore times on feed. Mean chain-wide gross margins within the optimum end-point selection method were also significantly different ($P < 0.01$) from one another.

Mean gross margins for the 4 treatments within the optimum end point selection were 21, 48, 2, and 13 dollars per progeny higher than fixed end point gross margins for treatments 1 to 4, respectively. Variability in gross margins increased from fixed to optimum end point as well, due to progeny performance levels being optimized for each sire. The largest difference across fixed and optimum gross margins was IMF discounts for treatment 2. Treatment 2 had the largest change in expected phenotype, with mean age at slaughter going from 386 to 434 d (a difference of 48 d) and an increase in all mean phenotypic levels. Treatment 3 had the smallest change in expected phenotype, with mean age at slaughter going from 386 to 396 d (a difference of 10 d). The small change in mean age resulted in the smallest increase in other expected mean phenotypic measures. Difference in gross margins in the fixed and optimal end point selection methods were significantly different from zero ($P < 0.01$), except for treatment 3.

Bull Rankings

Rankings over the fixed and optimum end point selection method within each of the various treatments were highly correlated (Table 7) with no rank correlation coefficient less than 0.96. The strong association between the fixed and optimum endpoints indicates there might be little value in determining optimized endpoints for progeny. If decision makers utilize bull rankings as an aid in choosing a few highly ranked bulls for use, the position of change in ranking might have more impact.

Change in rank correlations was greatest in treatment 2 as related to the quality index factors in which increasing quality discounts were applied to cuts with lower IMF. Emphasis through optimization is placed on an end point that achieves higher IMF. There are 2 ways to achieve higher IMF in this model, progeny from a genotype that supports high IMF and a longer time on feed. In the case of treatment 2, the mean optimized end point for BF was 12.4 mm. In terms of days on feed (age at end point attainment minus 200 d), the optimized group average was 234 vs. 186 d for the fixed end point group. With the added time on feed, other traits that contribute to retail product and feed efficiency become increasingly important, and the various combinations of traits represented by different bulls will prove to be increasingly important in providing the correct ranking of bulls used to create progeny.

Change in progeny rankings between fixed and optimum end point selection was least in treatment 3, with a rank correlation coefficient of 1.00. Treatment 3 placed importance on size of certain retail cuts, specifically the REA of the progeny. Because the quality index pressure is for an average sized to smaller LM, the emphasis is placed on an end point that achieves an average to smaller REA. The optimum end point selected for treatment 3 was 7.8 mm, and the time on feed was more similar to the fixed end point at 196 d on feed.

Bull rankings were not as highly related across quality indexing treatments as for optimized end point to fixed end point (Table 7). Bull rankings were affected most by indexing for IMF, with rank correlations between gross margins of progeny of bulls calculated with either quality indexing or not being 0.73 for the fixed end point and 0.84 for the optimized end point. Correlations were reduced by indexing for both IMF and REA relative to no indexing to 0.63 for the fixed end point, and 0.71 for optimized end point.

DISCUSSION

The boundaries of the model and range of parameters examined in this study must to be considered in interpreting results. The model used was designed to represent the complete beef supply chain and is an integrated production and marketing model. No cropping activities were included, no resource constraints applied, and no effects of volume of production on prices were considered. In the current study, only a limited number of parameters were changed, in particular those parameters relating to expected genetic levels of progeny of bulls available for use. Only one standard feeding program was included in the study. Interactions of genetics and feeding program were not considered, and optimizing combinations of genetics and feeding programs would be an interesting additional area of study. Similarly, only one set of mates of the bulls being ranked was considered. Wilton et al. (2002), for example, have shown the importance of average genetic levels of mates for weight and IMF in the ranking of bulls. Finally, one particular set of market prices for retail product was included with price differences for IMF and REA. Wade et al. (2001), for example, have shown an effect on breeding strategies for markets differing in prices for varying levels of IMF and carcass weight.

The current study also included only a subset of traits for which genetic evaluations are available. Results were based on terminal use of bulls only, even though the bulls ranked in the study were from a composite breeding system. Greater differences might have been found for bulls of a terminal breed. Genetic evaluations were also not available for fat distribution (other than subcutaneous and intramuscular) or for muscle distribution. The latter might have particular interest in the detailed product yield pricing approach in this study, if there were, in fact, genetic differences in muscle distribution. Genetic evaluations were also not included for feed intake during the finishing phase. Feed intake was predicted from equations modified to include genetic differences in fat deposition and growth rate, rather than from genetic evaluations for feed intake directly. Optimization of gross margins might have been more important had more specific genetic information been available.

One of the key assumptions in the model is that equations accurately predict changes in phenotypes over time, depending on fat deposition and weight changes. All genetic evaluations were age-constant, although as with all age-constant evaluations observations taken at other points in time were linearly adjusted to a 365-d basis. Further parameterization of the methods of predicting days of age at a given finish might be appropriate, particularly for varying feeding programs.

The results presented relate to comparisons of optimized progeny gross margins with those at a fixed BF end point. The model allows for choices of differing endpoints such as age or weight being fixed, and comparisons to those end points might not be identical to those for a fixed BF end point. Optimization was on a bull-by-bull basis and, as a result, the optimum combination of days on feed, BF depth and weight of progeny was different for each bull. Similarities of rankings of bulls for fixed and optimized endpoints may be due to similarities of the fixed BF level used with average predicted BF depth under optimization. Similarities of rankings may also be due to the single genetic level of mates studied, or the sample of bulls used with their particular ranges of economically important characteristics.

The impact of indexing for REA alone was less than that for IMF. In this project, area of LM was considered to be the factor of economic importance relative to carcass size, with a lower percentage of retail cuts being affected by discounting than for IMF. The importance of muscle dimensions might differ in other markets, leading to different rankings of sires for the use of their progeny in those differing commercial settings.

Optimization has been discussed more often in terms of establishing selection objectives, for example by Smith et al. (1986) and Amer et al. (1993), than for ranking animals for commercial production. Optimizing management was shown to be an integral part of establishing the equivalence of economic weights for breeding objectives at constant age, weight, or BF endpoints by Wilton and Goddard (1996). Changes in bull rankings in this study at least indicate that careful considerations of marketplace, as well as production program and mating program, are necessary in developing economic values for beef breeding objectives.

Present results relate to the commercial evaluation of bulls based on predictions of progeny performance using across-breed, age-constant EPD. The model used is similar to the model described by Wilton et al. (2002) and was designed to provide customized bull ranking procedures for commercial producers. The model incorporates detailed consideration of retail values of product and could be used to examine other market pricing structures as well.

IMPLICATIONS

Optimization of market end point at the level where gross margin is maximized could influence rankings of bulls on the basis of expected progeny performance, although changes in ranking may be small depending on how closely fixed levels of end point reflect optimum levels. Changes in rankings for differential prices for retail products due to factors such as IMF as an indicator of quality of product, or REA as an indicator of size of retail steaks, indicate a need for consideration of markets, as well as production programs, in choosing beef bulls.

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