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PRODUCTION, CARCASS CHARACTERISTICS AND VALUABLE CUTS OF PUREBRED SIMMENTAL AND SIMMENTAL × BEEF BREED CROSSBRED BULLS IN FINNISH BEEF CATTLE POPULATION*

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Abstract

The objective of the present research was to study the potential for improvement of growth and carcass traits through Simmental (Si) × beef breed crossbreeding compared to purebred Si bulls in Finnish beef cattle population. The data collected from Finnish slaughterhouses included observations of 6 224 purebred Si bulls plus Si × beef breed crosses. For estimating valuable cuttings, a separate dataset including in total 314 bulls was also collected. The estimated average daily carcass gain of the purebred Si bulls was 686 g/d and it improved by 3 and 6% with Si×Blonde d'Aquitaine and Si×Charolais crossbreds, respectively. Carcass conformation improved by using Blonde d'Aquitaine, Limousin and Charolais crossbreeding compared to the pure Si bulls. Si×British breed crossbreds (Angus and Hereford) had poorer carcass gain and produced poorer conformed carcasses compared to purebred Si bulls. Furthermore, the yield of subcutaneous fat was higher in the Si×Angus and Si×Hereford bulls than in the purebred Si bulls.

Key words: beef production, breeds, bulls, carcass characteristics, crossbreeding

Traditionally the majority of beef in Finland has been produced by dairy breeds (Huuskonen, 2014). However, the decrease in the number of dairy cows has diminished the supply of calves for beef production originating from dairy herds. Because the supply of domestic beef has been decreasing, there is nowadays a clear discrepancy between the demand for and supply of domestic beef. Therefore the need for beef-breed calves is increasing at present. In total, 12 beef breeds are currently kept in Finland, and Aberdeen Angus (Ab), Blonde d'Aquitaine (Ba), Charolais (Ch), Hereford (Hf), Limousin (Li) and Simmental (Si) are the six most frequently used

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breeds. Previously, Pesonen and Huuskonen (2015) examined growth and carcass traits of pure beef breeds in Finnish beef cattle population and concluded that the later maturing Continental breeds (Ba, Ch, Li, Si) seem to reach higher carcass gains, produce less fat and have more valuable cuts than the earlier maturing British beef breeds (Ab, Hf). The later maturing beef breeds tended to have carcass traits that suit well in the Finnish beef production system and Finnish beef markets (Pesonen and Huuskonen, 2015).

However, the decision to opt for a breed depends not only on the growth performance and carcass characteristics but also on the other aspects affecting the beef production. Maximizing profit potential in beef production usually requires matching the genetic potential of the animals with available resources. The genetic potential of milk yield differs between breeds and greatly influences several important production traits, e.g. calf performance, dam's nutritional needs and rebreeding rates (Mallinckrodt et al., 1993). The maternal ability of beef cows has been shown to be a critical component of pre-weaning growth in their calves (Fiss and Wilton, 1993; Mallinckrodt et al., 1993). Weaning weight affects the profit potential of the beef herd, especially when selling beef calves (Miller et al., 1999). Improving the milk producing ability of dams could increase gain to weaning and average daily gain in feedlot, which would have a positive impact to productivity (Fiss and Wilton, 1993; Miller et al., 1999). The maternal breed effect of Simmental has been shown to exceed most common beef breeds in crossbred beef cattle (Kress et al., 1990; Roso et al., 2005).

Crossbreeding is the mating of individuals from different lines, breeds, or populations. There are two main reasons for applying crossbreeding within livestock (Sørensen et al., 2008). The first is to utilize the different additive genetic levels between breeds to generate offspring with better economic ability caused by new combinations of additive genetic components. Second, crosses between pure lines/breeds express heterosis. Crossbred animals are more robust and economically efficient compared with the parental breeds (Mäki-Tanila, 2007). It has been known for a quite awhile that heterosis is an important and easy factor for increased productivity in beef cattle (Mason, 1966; Dillard et al., 1980).

Differences between individual beef breeds and breed groups in growth performance and carcass traits have been extensively evaluated earlier, for example, by Bartoň et al. (2006), Alberti et al. (2008) and Pesonen et al. (2012, 2013 a, b). However, the amount of experimental animals is often limited when growth and carcass characteristics of different breed groups are compared. Consequently, there is a concern about the representativeness of the experimental animals compared with other animals from the same breed groups, i.e. whether they cover the whole variation in their respective populations. In addition, breed comparisons are mainly relevant for their specific production conditions and genetic level. Therefore, the objective of the present research based on a dataset collected from slaughterhouses was to study the potential for improvement of growth and carcass characteristics through Si×beef breed crossbreeding compared to purebred Si bulls. It was hypothesized that the use of late maturing crossbreds (Ba, Ch, Li) improves carcass production compared to purebred Si bulls.

Material and methods

Dataset – complete slaughter data

Dataset used in the present study was collected from four Finnish slaughterhouses [A-Tuottajat Ltd. (Seinäjoki, Finland), HK-Agri Ltd. (Turku, Finland), Saarioinen Lihanjalostus Ltd. (Tampere, Finland) and Snellman Lihanjalostus Ltd. (Pietarsaari, Finland)]. These slaughterhouses are the major meat companies in Finland, which, as a part of their business operations, transfer calves from dairy farms, or suckler cow herds, to co-operating farms for fattening, and slaughter the animals. A raw slaughter data for each animal included individual animal identification number on ear tag, date of birth, date of slaughter, sex, carcass weight, carcass conformation score and carcass fat score. Identities of breeds (dam and sire breed) were collected from the National Animal Identification Register for Cattle (ProAgria Agricultural Data Processing Centre, Vantaa, Finland). Slaughtering data and identities of breeds for individual animals were linked through individual animal identification numbers. All purebred Si bulls as well Si×beef breed crossbred bulls aged 365–730 days old and slaughtered by above-mentioned slaughterhouses in 2009–2011 were selected for the study.

Table 1. Description of the experimental data

Item	n	Mean	SD	$q_{0.05}$	$q_{0.95}$
Dataset (complete slaughter data)					
age at slaughter (d)	6 224	565	57.4	465	650
carcass gain (g/d)	6 224	685	108.5	511	862
carcass weight (kg)	6 224	401	60.7	295	495
conformation score (1 = poorest, 15 = excellent)	6 221	8.3	1.93	5	11
fat score (1 = leanest, 5 = fattest)	6 224	2.5	0.79	1	4
Dataset (commercial cutting)					
age at slaughter (d)	314	570	52.4	478	651
carcass gain (g/d)	314	633	112.7	423	814
carcass weight (kg)	314	375	64.7	266	469
conformation score (1 = poorest, 15 = excellent)	314	7.6	1.71	5	11
fat score (1 = leanest, 5 = fattest)	314	2.4	0.74	1	4
From yield (g/kg)					
subcutaneous fat	313	38.0	14.11	18.8	64.6
loin (*M. longissimus*)	299	41.1	3.44	36.0	46.4
tenderloin (*M. psoas major*)	294	14.7	1.18	12.8	16.7
inside round (*M. semimembranosus*)	303	40.7	3.99	35.0	46.4
outside round (*M. semitendinosus*)	301	65.1	5.26	57.0	72.0
corner round (*M. quadriceps femoris*)	302	36.3	2.76	31.7	40.9
roast beef (*M. gluteus medius*)	309	19.2	1.95	16.0	21.8

SD – standard deviation.
$q_{0.05}$-quantile – approximately 5% of the data has a value less than the 0.05-quantile.
$q_{0.95}$-quantile – approximately 95% of the data has a value less than the 0.95-quantile.

After slaughter the carcasses were weighed hot in all of the slaughterhouses. The cold carcass weight was estimated as 0.98 of the hot carcass weight. The carcasses were classified for conformation and fatness using the EUROP quality classification. For conformation, development of carcass profiles, in particular the essential parts (round, back, shoulder), was taken into consideration according to the EUROP classification (E: excellent, U: very good, R: good, O: fair, P: poor). Each level of the conformation scale was subdivided into three sub-classes (e.g. O+, O, O–) to produce a transformed scale ranging from 1 to 15, with 15 being the best conformation. For fat cover, the amount of fat on the outside of the carcass and in the thoracic cavity was taken into account using a classification range from 1 to 5 (1: low, 2: slight, 3: average, 4: high, 5: very high).

Birth weight assumptions used in calculations were 46 kg live weight for purebred Si and Si×late maturing breed calves and 44 kg live weight for Si×early maturing breed calves (Åkerlind et al., 2011). Birth carcass weight was assumed to be 0.4 × birth weight since the same values were used by Atria Ltd. in daily extension work (Herva et al., 2009, 2011). An estimated daily carcass gain was calculated by subtracting birth carcass weight from the reported slaughter weight and dividing the result by age at slaughter. The complete final slaughter data comprised 6 224 slaughtered bulls; the average slaughter age was 565 days and the mean carcass weight 401 kg (Table 1). The average estimated daily carcass gain was 685 g/d, the EUROP conformation score 8.3 and the carcass fat score 2.5.

Dataset – commercial cutting

For estimating valuable cuttings for studied breeds a separate dataset was collected during 2010–2011 from Snellman Lihanjalostus Ltd. In addition to abovementioned variables this dataset included also information of commercial cuttings. After classification carcasses were chilled overnight below 7°C. Day after slaughter the carcasses were commercially cut. Each carcass was cut into valuable cuts [outside round (*Musculus semitendinosus*), inside round (*Musculus semimembranosus*), corner round (*Musculus quadriceps femoris*), roast beef (*Musculus gluteus medius*), tenderloin (*Musculus psoas major*) and loin (*Musculus longissimus*)] and tallow (subcutaneous fat) as described by Pesonen et al. (2013 b) and Huuskonen et al. (2014). The amount of tallow was evaluated by cutting off the visible subcutaneous fat on the surface of primal cuts and by weighing the yield of tallow in grams. All these cuttings were weighed automatically in the slaughter line and their yields were expressed as percentages of the carcass cold weight (0.98 × carcass hot weight, 50 min *postmortem*). This dataset comprised 314 slaughtered bulls (Table 1). The average carcass gain, carcass weight and carcass conformation score were 8, 6 and 8% lower, respectively, in this dataset compared to the complete slaughter data (Table 1).

Statistical methods

The results are shown as least squares means. The normality of residuals and the homogeneity of variances were checked using graphical methods: box-plots and scatter plots of residuals and fitted values. The data were subjected to the analysis of variance using the SAS Mixed procedure (version 9.4, SAS Institute Inc., Cary, NC).

The model used was:

$$y_{ij} = \mu + \alpha_i + e_{ij}$$

where:

μ is the overall mean,
e_{ij} is the random error term,
α_i is the effect of breed.

Effects of slaughterhouse location and age at slaughter were not taken into consideration in the final statistical model because these effects were quantitatively minimal and they were considered not to have importance from a practical point of view. Differences between the breeds were compared using Dunnett's test so that purebred Si was used as a control breed. P-values less than 0.05 are reported as statistically significant.

Results

The complete slaughter data included 2 152 purebred Si bulls (Table 2). The most popular crosses were Si×Hf (1 033 observations), Si×Li (999) and Si×Ch (980), while Si×Ab (805) and Si×Ba (255) crosses were used less. The average slaughter age for the purebred Si bulls was 565 days, and there were no major differences in the average slaughter age among the breed groups. However, the Si×Ch bulls were 12 days younger ($P<0.001$) and Si×Hf bulls 5 days older ($P<0.05$) compared to the purebred Si bulls (Table 2).

All crossbred groups differed significantly from the purebred Si bulls in both carcass weight and carcass gain (Table 2). The estimated average daily carcass gain of the pure Si bulls was 686 g/d, and it improved by 3 and 6% with Si×Ba and Si×Ch crossbreds, respectively, compared to the Si bulls. Instead Si×Ab, Si×Hf and Si×Li bulls grew 2–3% slower than the pure Si bulls. The average carcass weight of the Si bulls was 402 kg, and it increased by 3% with Si×Ba and Si×Ch crossbreds and decreased by 1–2% with Si×Ab, Si×Hf and Si×Li crossbreds compared to the pure Si bulls (Table 2). The EUROP conformation score of the purebred Si bulls was 8.3, and improved 10, 7 and 2% by using Ba, Li and Ch crosses, respectively. Si×Ab crossbreds produced 7% and Si×Hf crossbreds 8% poorer conformed carcasses compared to the purebred Si bulls. The carcass fat score of the Si×Ab, Si×Hf and Si×Li bulls was 22, 22 and 4% higher than that of the pure Si bulls, respectively (Table 2). There were no differences in carcass fat score between Si and Si×Ba bulls or between Si and Si×Ch bulls.

Table 2. Carcass gain, carcass characteristics and valuable cuts of purebred Simmental (Si) and Si×beef breed crossbred bulls in Finnish slaughter dataset. Ab = Aberdeen Angus, Ba = Blonde d'Aquitaine, Ch = Charolais, Hf = Hereford, Li = Limousin

Item	Breed group						SEM	P-value	Statistical significance				
	Si×Si	Si×Ab	Si×Ba	Si×Ch	Si×Hf	Si×Li			Si×Ab	Si×Ba	Si×Ch	Si×Hf	Si×Li
Dataset (complete slaughter data)													
n	2 152	805	255	980	1 033	999	-	-	-	-	-	-	-
age at slaughter (d)	565	566	566	553	570	569	3.6	<0.001			***	*	
carcass gain (g/d)	686	675	709	725	664	669	6.7	<0.001	*	**	***	***	***
carcass weight (kg)	402	396	414	414	393	394	3.8	<0.001	*	**	***	***	***
conformation (1 = poorest, 15 = excellent)	8.3	7.7	9.1	8.9	7.6	8.5	0.12	<0.001	***	***	***	***	*
fat score (1 = leanest, 5 = fattest)	2.3	2.8	2.2	2.3	2.8	2.4	0.05	<0.001	***			***	**
Dataset (commercial cutting)													
n	154	32	19	20	48	41	-	-	-	-	-	-	-
age at slaughter (d)	566	563	583	580	589	556	11.9	0.02				*	
carcass gain (g/d)	669	602	628	601	558	627	24.3	<0.001	**		*	***	
carcass weight (kg)	393	351	380	360	346	364	14.3	<0.001	**			***	*
conformation (1 = poorest, 15 = excellent)	7.9	7.0	8.1	7.8	6.6	7.8	0.38	<0.001	*			***	
fat score (1 = leanest, 5 = fattest)	2.4	2.7	2.3	2.4	2.7	2.2	0.17	0.009				*	
From yield (g/kg)													
subcutaneous fat	37.0	44.5	32.3	35.9	44.3	33.0	3.12	<0.001	*			**	
loin (*M. longissimus*)	41.3	39.0	41.2	41.8	40.7	41.8	0.77	0.008	**				
tenderloin (*M. psoas major*)	14.7	14.1	14.9	14.6	14.4	15.0	0.27	0.049	o				
inside round (*M. semimembranosus*)	41.0	38.7	41.3	42.3	38.9	42.2	0.90	<0.001	*			**	
outside round (*M. semitendinosus*)	65.4	62.9	66.9	67.3	62.5	66.8	1.19	<0.001	o			**	
corner round (*M. quadriceps femoris*)	36.0	35.3	38.0	36.8	35.8	37.7.	0.61	<0.001		*			**
roast beef (*M. gluteus medius*)	19.4	18.0	19.1	19.8	18.2	20.0	0.43	<0.001	***			***	

SEM – standard error of mean.
Statistical significance – differences between the breed groups were compared using an a priori test (Dunnett's test) so that purebred Si was used as a control breed.
*** (P<0.001), ** (P<0.01), * (P<0.05) and o (P<0.10).

Dataset from commercial cuttings included 154 purebred Si bulls but the amount of the crossbreds was less (19–48 bulls/breed group) (Table 2). Breed group had effects on the yield of valuable cuts, so that in particular Si×Ab and Si×Hf bulls differed from the purebred Si bulls. The yields of loin, tenderloin, inside round, outside round and roast beef were lower with the Si×Ab bulls compared to the pure Si bulls. With the Si×Hf crosses the yields of inside round, outside round and roast beef were lower compared to the Si bulls. Furthermore, the yield of subcutaneous fat was significantly higher in the Si×Ab and Si×Hf bulls than in the purebred Si bulls. There were only few differences in the yield of valuable cuts between the pure Si bulls and Si×late maturing crossbreds (Table 2). However, the yield of corner round was higher in the Si×Ba and Si×Li bulls compared to the Si bulls.

Discussion

The main objective of the present study based on the dataset collected from slaughterhouses was to study growth and carcass traits of Si crossbred bulls compared to purebred Si bulls in Finnish beef cattle population. In Finland beef breed bulls are typically housed and fed consistently in commercial finishing farms, i.e. different methods are not used for different breed groups within a finishing farm. Therefore, it can be assumed that the results of the present data give a good representation of the differences between the studied breed groups. Overall, it is difficult to make direct comparisons between the present field data and earlier experiments because in a single experiment an individual factor (e.g. slaughter age, carcass weight, intramuscular fat content) could be used as the end point of the study. In other words, a limitation of the present field data is that the breed effects are partly confounded with, for example, carcass weight. However, the observed carcass weights are nowadays the average weights for slaughtered bulls of these breed groups in Finland, and therefore, the present results are valid from a practical point of view.

Consistent with the literature (e.g. Arango et al., 2002; Williams et al., 2010) the carcass gain, carcass weight and conformation score were higher in the Continental crosses than in the British crosses. In the present study, especially Ch and Ba influenced progeny had high carcass gains, carcass weights and conformation scores compared to the purebred Si bulls. Previously, a high growth rate of Ch bulls was observed, for example, by Bartoň et al. (2006) and Albertí et al. (2008) in pure breeds and by Andersen et al. (1977) and Huuskonen et al. (2014) who used Ch in a crossbreeding study. In accordance with our results, Williams et al. (2010) concluded that Ch had the most positive and British breeds the most negative effect on post-weaning growth.

Similarly to our findings, Gregory et al. (1991, 1994 a, b) reported that Si steers had higher average daily gains than Ab and Hf steers after a constant time on feed. On the contrary, Mandell et al. (1998) reported that medium framed Hf steers gained more than large framed Si steers when fed to a common backfat endpoint presumably due to a shorter time on feed and higher efficiency for maintenance and gain.

Hereford gained more rapidly and more efficiently while Simmental had heavier and leaner carcasses (Mandell et al., 1998).

Consistent with the present data, Arango et al. (2002) concluded that the Continental breeds have the most positive effect on carcass weight as they are known to be larger framed and late maturing breeds, which is associated with heavier carcasses. On average, the carcass traits are higher in late maturing breeds than in maternal breeds (Albertí et al., 2008). The lean yield has been higher in the Continental breeds after constant time on feed (Gregory et al., 1994 a, b) or at common backfat end point (Mandell et al., 1998). Generally, the later maturing breeds also produce more retail saleable product which has been shown by Bartoň et al. (2006), Albertí et al. (2008) and Holló et al. (2012).

Bartoň et al. (2006) reported that proportions of meat in higher priced joints were higher in Si bulls compared to Ab and Hf bulls. Higher lean yields were also recorded in carcasses from purebred Si compared to Hf steers (Mandell et al., 1998) and from purebred Si compared to Red Angus steers (Laborde et al., 2001).

In general, Continental breeds tend to produce leaner carcasses than British origin breeds (Hassen et al., 1999; Arango et al., 2002; Rios-Utrera et al., 2006), and this was also the case in the present data. Previously, Williams et al. (2010) reported that Ab had the most pronounced effect on fat thickness whereas Continental breeds decreased the fat thickness, and Wheeler et al. (2005) observed that Hf-sired steers were fatter than Ch-sired steers when slaughtered at constant age. Similarly, Schenkel et al. (2004) reported with purebred beef bulls that Ba bulls showed the least backfat thickness, followed by Li, Ch and Si when breed differences for growth and body composition traits were studied in Ontario bull test stations from 1991 to 2000. In that case, the Hf bulls had the highest level and the Ab bulls the second highest level of backfat thickness (Schenkel et al., 2004).

Conclusions

Overall, significant breed differences were observed in growth performance, carcass traits and retail product yield. The daily carcass gain improved by using Ba and Ch crossbreeding and carcass conformation improved by using Ba, Li and Ch crossbreeding compared to the pure Si bulls. Si×British breed crossbreds had poorer carcass gain and produced poorer conformed carcasses compared to purebred Si bulls. Furthermore, the yield of subcutaneous fat was higher in the Si×Ab and Si×Hf bulls than in the purebred Si bulls.

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