Evaluating crossbreeding beef on dairy for the South African dairy Industry

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Abstract
Beef production is a natural possibility in dairy herds through culled cows and rearing bull calves for veal or beef production. This potential is not always exploited fully, probably because of its relatively small contribution to overall farm income. Studies were conducted comparing different breeds in crossbreeding programs towards improving milk output, fertility and beef production potential through rearing of dairy and crossbred bull calves as veal or beef. Initially, Jersey cows in a pasture-based system were serviced by Belgian-Blue and Limousin sires. Crossbred bull and heifer calves were reared on pasture to 24 months of age and growth rate parameters compared to Jersey steers. At marketing, the live weight of crossbreds was heavier than Jersey steers, although lower than expected because of poor pasture quality and utilization. Further crossbreeding studies included Holstein and Jersey cows serviced by either purebred sires or Fleckvieh sires, a Simmentaler-derived breed from Germany. Pure- and crossbred bull calves were reared intensively as veal to live weights of approximately 200 kg to ensure a carcass weight not exceeding 100 kg. Another group of bull calves were reared as beef to 21 months of age on rain-fed pasture. As expected, the daily live weight gain was higher in crossbred bull calves and steers compared to Jersey calves and steers, while not differing between Fleckvieh x Holstein and Holstein bull calves and steers. A preliminary study also indicates that the pure Holstein bull calves may perform well in the feedlot. Results indicate a potentially higher beef income for crossbred veal calves and steers. Further studies are required to determine an optimal feeding program and marketing age as well as its effect on beef quality characteristics.

Keywords: Breed comparison, Fleckvieh, Belgian Blue, dairy breeds, veal and beef production
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Introduction
Beef production is a natural possibility in dairy herds through culled cows while bull calves can be reared for veal or beef production. This potential is however often not exploited fully, probably because of its relatively small contribution to overall farm income. In South Africa beef contribution from dairy herds is estimated to be about 10% of the total beef production. This is probably because of a small national dairy *vs*. beef herd and the fact that large Jersey (J) populations are popular in pasture-based areas. Another reason may be opposition to crossbreeding by breed societies as crossbred animals are not accepted for registration purposes. For J farmers, little income is generated from rearing bull calves, because of the growth rate of culled cows and steers is low compared to other dairy or beef breeds with typical yellow fat (Burke *et al*., 1998). Furthermore, because of the poor growth rate potential of J steers there is a low demand for uptake in the feedlot industry. However notwithstanding poor growth rates J bull calves are popular among new (emerging) farmers because of their availability, and generally, low prices (Muller, 2014).

As crossbreeding is increasingly being considered as an option to overcome specific problems in dairy herds, notably to improve fertility in dairy cows (Heins *et al*., 2006), beef production output of J herds could be improved using beef or dual-purpose breed sires on a part of the dairy herd. Using this management tool requires that all progeny from crossbreeding be culled. This practice can only be applied in stable dairy herds maintaining low culling rates among cows and successful heifer rearing to first calving. While crossbreeding is a common practice in New Zealand dairy herds, i.e. crossbreds comprise about 35% of all cows in the national herd, which is mostly Holstein-Friesian sires on J cows or vice versa. The aim is mainly to improve the milk production performance of the herd through higher milk yields, better milk composition, fertility and longevity.

Burke *et al*. (1998) in New Zealand showed that the disadvantages of poor beef production from J cows can be offset by crossbreeding part of the dairy herd with suitable beef breeds. In Europe the contribution to beef from dairy herds constitute about 60% of all beef production; mostly because of a larger dairy *vs*. beef population (Toplif, 2010). Nearly one third of bull calves are fattened as veal. In the USA beef from dairy herds amounts to about 21% (Geiser & Boetel, 2019) of beef production. Zehetmeier *et al*. (2012) suggested that dual-purpose breeds are required for milk production to maintain beef production in Europe because of a potential decrease in dairy cow numbers due to higher milk yields.

More than 50 years ago, some studies were done in South Africa to improve the production potential of meat in specifically J herds. It was found that J crossbred offspring compares favourably with crossbreds of indigenous cattle breeds such as the Afrikaner (Naude & Boccard, 1973). It was also reported that that the birth weights and slaughter weights at 15 months of age were higher in Simmentaler (S) x J and Brown Swiss x J young bulls or oxen (intact or castrated) than in similar J calves (Naude & Armstrong, 1967). More recent studies by Muller *et al*. (1999), indicated that S x J calves had similar growth rates as pure S calves, i.e. 0.699 *vs*. 0.709 kg per day, when raised on oats and kikuyu pastures, with a concentrate supplementation of 0.5 kg/day.

In the early 1960's the potential of the Belgian Blue (BB) breed was already considered to improve beef production in crossbreeding programmes with dairy cattle (Butterfield, 1966). The BB carries the genes for double muscling or muscle hypertrophy (Arthur, 1995). The theory was that using the BB in crossbreeding programmes with dairy breeds should improve feed efficiency, meat yield and meat tenderness (Arthur, 1995). A study conducted by Arpacik *et al*. (1993) showed that BBxJ bulls had significantly higher growth rates when compared to purebred bulls.

This paper aims to present results from local studies on crossbreeding towards improving the beef production potential from dairy herds. Two beef production studies were part of a crossbreeding project that included the use of the BB and Limousin (Lim) sires on J cows and BB sires on H cows under commercial farming conditions. Three other studies used Fleckvieh (F) sires, a Simmental derived dual-purpose breed from Germany, on Holstein (H) and J cows towards improving the milk composition, fertility and longevity of cows. Pure- and crossbred bull calves in these studies were compared in both veal and beef production systems. The results from these studies will be presented and discussed, followed by a general conclusion and recommendation.

Crossbreeding studies

1. Belgian Blue and Limousin vs. Jersey

In this study (Muller *et al*., 2004) the growth rate and live weight of BB and Lim steers and heifers were compared to J steers. Dairy farming in the area is based on cultivated pastures, i.e. ryegrass (*Lolium mulitflora* and *L. perenne*) and kikuyu (*Pennisetum clandestinum*) under permanent irrigation systems. Jersey cows from second parity and older that weighed at least 350 kg, were randomly inseminated with BB or Lim semen. Calving ease, scored from one (cow calving without any assistance) to five (birth by caesarean procedure), was recorded for cows giving birth to a crossbred calf. All calves were reared similarly, i.e. receiving a 19% crude protein (CP) pelleted commercial calf starter meal from seven days of age. At two months of age, calves were moved to cultivated kikuyu-ryegrass pasture, where they received 2 kg per day of a 16% CP pelleted commercial calf growth meal. At six months of age the calf growth meal was reduced to 1.5 kg/calf/day. This was fed to all J steers and crossbred heifers and steers until slaughter at 24 months of age. Bull calves were castrated at two months of age with a Burdizzo. The traits recorded at slaughter were live weight, carcass weight, dressing percentage and carcass grades.

As expected, sire breeds affected ($P<0.01$) all growth traits of heifers and steers (Table 1). Purebred J calves were smaller ($P<0.001$) at birth (23.7 *vs*. 30.5 and 32.2 kg) than Lim and BB crossbred calves, respectively. Jersey steers also had a lower ($P<0.05$) growth rate (0.338 *vs*. 0.401 and 0.431 kg/day) compared to Lim and BB heifers and steers, resulting in lower live weights at slaughter. The J steers had lower (P<0.01) carcass weights and dressing percentage than that of the crossbreds. Most of the cows (75%) calved down without any assistance and sire breed had no effect on calving difficulties. Likewise, gender of the calves had no effect ($P>0.05$) on birth weight, calving ease, live weight at 24 months of age, carcass weight and dressing percentage.

Table 1 The mean±se growth rate parameters for steers and heifers as affected by sire breed in a pasture-based production system (Muller *et al*., 2004)

	Sire breeds			
Parameters	Jersey	Limousin	Belgian Blue	*P*
Number slaughtered	4	11	18	-
Birth weight (kg)	23.7±0.9	30.5±0.8	32.2±0.6	0.01
Calving ease (score 1-5)	1.1±0.1	1.3±0.1	1.2±0.1	0.35
Live weight at 24 m of age (kg)	272±23	323±16	347±10	0.02
Average daily gain (g)	338±31	401±22	431±14	0.03
Carcass weight (kg)	137±12	164±9	187±6	0.001
Dressing percentage (%)	46.4±1.5	49.7±1.1	51.8±0.7	0.01

Results from this study concur with that of Arpacik*et al.* (1993) who found that BBxJ steers weighed 35 kg at birth, with very few calving problems among J cows. In that study, the average daily gain of crossbred steers was 0.844 kg per day reaching 305 kg at 320 days of age.

While the growth rates of crossbred steers were lower than in other studies, the performance of Lim and BB crossbred steers was 30% higher than that of purebred J steers. This will result in a higher income for farmers from crossbred steers. If higher quality pasture and supplementary concentrate can be provided to the steers, the growth rates may increase albeit that the feeding cost will also increase.

2. Belgian Blue vs. Holstein

This study (Gray, 2006) was conducted at the Cedara Research Farm and some participating commercial dairy farms in the KwaZulu-Natal region of South Africa. Belgian Blue (BB) semen straws were provided to dairy farmers to be used on H cows on a random basis within a four month period. Participating dairy farmers undertook to record birth dates, gender of crossbred calves born, calving ease (or mortality), birth weight of calves born alive and live weights of calves at specific age intervals as well as slaughter data. Belgian Blue semen was provided by the Linalux Co-operative, Ciney, Belgium and was distributed by the Taurus Co-op (SA). The second round of semen was imported and distributed by Genimix SA. All BB bulls used in the study were selected on the basis of their below average estimated breeding value for birth weight to prevent calving problems. The study was supervised by an extension officer of the Department of Agriculture, KwaZulu-Natal region. Results from this study have not been subjected to statistical analyses complicating interpreting final results. However as this was a major study comprising a number of participants with some international involvement, it was decided to include the results as presented in an official departmental report.

Semen was distributed during two rounds. A total of 429 semen straws were used (81% utilization of straws handed out) by dairy farmers. Semen was used on 336 cows resulting in 126 cows being confirmed pregnant. The conception rate was 29.4% (3.40 straws per conception).

The number of calves born alive was 104 (82% of cows confirmed pregnant) while 16 (13%) calves died at birth and 6 (5%) abortions were recorded. About 78% of cows calved down without any assistance while only 15% required assistance during calving down. This number of assists is within the normal level for dairy cows, indicating that crossbred BB calves did not increase calving problems in H cows. As expected the birth weight of crossbred bull calves was higher than crossbred heifers being on average 45.2 *vs*. 41.2 kg respectively. Body size measurements of pregnant cows show that despite large variations in cow live weight (450-700 kg), shoulder height (112-147 cm) and birth weight (29-52 kg), the difference in the mean ratios between BBxH and H calves birth weights to dam body weight and shoulder height were negligible, being 7.5 *vs*. 7.1 and 32.9 *vs*. 30.5 respectively.

Growth rates for BBxH and H bull and heifers calves were generally poor (Table 2) probably reflecting poor pasture quality and young calves not well adapted to grazing. No information is available on whether supplementary feeding was provided as this may have differed among farms. Only a limited number of records was provided by participating farmers.

Table 2 The mean growth rate parameters for Belgian Blue x Holstein (BBxH) and Holstein (H) bull and heifer calves (Gray, 2006)

	BB x H		Holstein	
Parameters	Bulls	Heifers	Bulls	Heifers
Number of calves	4	5	8	5
Birth weight (kg)	43.8	41.0	37.9	39.4
100d Live weight (kg)	78.6	85.6	71.8	71.1
205d Live weight (kg)	127.5	119.4	121.4	105.5
365d Live weight (kg)	222.6	186.0	193.7	195.4
504d Live weight (kg)	302.8	278.2	270.3	281.2
ADG to 504d (kg)	0.476	0.430	0.430	0.447

A limited number of BxH heifer (n=6) and bull (n=2) calves and H steers (n=12) were put through an 84-day feeding test period following a four week adaptation period. Final live weights for BBxH heifers, BBxH steers and H steers at about 22 months of age were 435, 476 and 446 kg respectively. This resulted in heifers and steers reaching average daily gains (ADG) of 1.524, 1.404 and 1.403 kg/day respectively. The feed conversion rate (FCR) for BBxH heifers, BBxH steers and H steers was 8.33, 9.12 and 9.54 kg respectively. These results seem to indicate a 6-10% advantage for BB crossbreds vs. H steers with regards to ADG and FCR's.

3. Fleckvieh vs. Holstein

In this study (Metaxas, 2015) the growth rate and live weight of FxH and H veal calves and steers were compared. Initially, H and FxH bull and heifer calves were sourced from a commercial dairy herd. Calves born at least five days earlier were moved to the research farm. Pure- and crossbred heifer calves were reared to first calving after which they were included in the research dairy herd. Holstein and FxH bull calves were reared either in an intensive veal production system, i.e. to a live weight of about 200 kg or a final carcass weight not exceeding 100 kg or as steers for beef production. Bull calves born within seven days of each other were reared for beef being marketed at 18 months of age.

All bull calves were fed full cream milk at 10% of body weight daily, up to 6 weeks of age when they were weaned. From seven days of age, a calf starter meal containing 18% CP was provided *ad libitum* until two months of age, where after the calves received a growth meal containing 15% CP *ad libitum*, up to marketing age. Veal calves were marketed before reaching a live weight of 200 kg to deliver a carcass weight not exceeding 100kg. After being fed intensively similarly to veal calves until six months of age, the steers to be used for beef production were moved to kikuyu pasture. These steers were supplemented with a 15% CP growth meal up to 12 months of age after which they were on rain-fed kikuyu pasture. All steers were marketed as close to 18 months of age as possible. Bull calves were dehorned and castrated at approximately two months of age with a Burdizzo.

The birth weights between H and FxH bull calves did not differ (P>0.05) and were 38.5±1.3 and 41.0±1.3 kg for H and FxH calves respectively (Table 3). While the live weight and average daily gain (ADG) of steers did not differ (P>0.05) between breeds at 18 months of age, polynomial growth curves (Figure 1) seem to indicate a faster growth rate from about 10 months of age, which may indicate genotype differences at a later age.

Table 3 The mean±s.e. growth rate parameters for Holstein and Fleckvieh x Holstein steers in rain-fed pasture production system (Metaxas, 2015)

Variables	Sire breeds		Significance level
	Holstein	Fleckvieh	
Number of records	16	14	-
Birth weight (kg)	38.5±1.3	41.0±1.3	0.20
Live weight at 18 months (kg)	445±16	473±20	0.29
Average daily gain (kg/d)	0.741±0.022	0.778±0.023	0.25
Hot carcass weight (kg)	213*± 7	232*±7	0.08
Cold carcass weight (kg)	207* ±7	226*±7	0.08
Dressing (%)	0.479±0.010	0.494±0.010	0.33

*Means within the same row differ at *P*<0.10

While the hot and cold carcass weights tended (*P*=0.08) to differ between H and FxH steers, the dressing percentage of carcasses did not differ (*P*>0.05) between breeds.

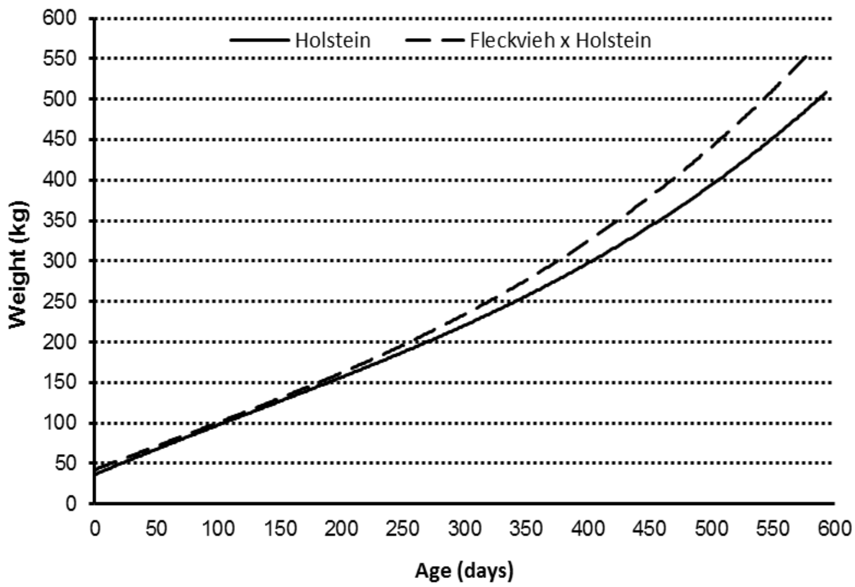


Figure 1 The live weight against age in days for Holstein and Fleckvieh x Holstein steers (Metaxas, 2015)

All variables, i.e. birth weight, weight at marketing, average daily gain, marketing age, hot and cold carcass weights did not differ (*P*>0.05) between H and FxH bull calves reared for veal (Table 4).

Table 4 The mean±s.e. growth rate parameters for Holstein and Fleckvieh x Holstein bull calves reared for veal in an intensive production system (Metaxas, 2015)

	Sire breeds		
Variables	**Holstein**	**Fleckvieh**	Significance level
Number of records	37	34	
Birth weight (kg)	40.0±0.79	41.2±0.81	0.32
Body weight at slaughter	202±1.7	199±1.7	0.16
Average daily gain (kg/d)	0.929±0.020	0.953±0.021	0.40
Hot carcass weight (kg)	101.5 ±1.2	101.2±1.3	0.86
Cold carcass weight (kg)	98.5±1.4	97.4±1.4	0.58
Dressing (%)	0.502±0.003	0.509±0.004	0.25
Marketing age (m)	5.87±0.17	5.85±0.11	0.95

This study confirmed the high value of H bull calves to be reared for veal or beef. It could be recommended that further studies are required to determine the optimal feeding programme to utilise the growth potential of crossbred bull calves to reduce marketing age as it is expected that the growth rate of FxH bull calves should be higher.

4. Fleckvieh vs. Jersey

In this study (Muller *et al*., 2013) the growth rate and live weight of FxJ and J veal calves and steers were compared. Two comparative pure- and crossbred dairy herds were established. The estimated breeding values for milk yield of the J cows were used to divide the cows of the research herd into two groups. These two cow groups were randomly inseminated with either semen of J or F bulls. During subsequent lactations and breeding occasions the alternative sire breed was used to inseminate the J cows. Progeny born from the J and F sires were inseminated with the same breed. The production performance of these pure J and FxJ cows as well as that of their progeny were compared on a pasture-based production system (Goni, 2014).

The pure- and crossbred bull calves were reared identical for the production of (i) veal, where the carcass weight did not exceed 100 kg, or (ii) beef, where the steers was marketed at 21 months of age. The calves for veal production were reared under intensive conditions using a commercial calf starter meal up to 2 months of age followed by a calf growth meal until marketing. In the beef production system, bull calves were castrated at approximately 2 months of age and reared identical to the veal production system up to 3 months of age, where after they were put on kikuyu pasture and supplemented with approximately 2 kg of a calf growth meal until the age 6 months. From 6 months of age, they were kept on rain-fed surplus cultivated pasture. During the dry summer months, additional oats hay was provided to steers. The animals had free access to fresh drinking water at all times.

Bull calves were weighed (birth weight) within the first 48 hours after birth when they were put into individual housing crates. Calves were weighed once a month using an electronic scale. When the veal calves reached a live weight of close to 180 kg, they were weighed every Thursday. When the bull calves reached a live weight of approximately 195 kg, they were marketed the following Tuesday. The calves were weighed before being transported to the abattoir (end live weight) and after slaughter. Both hot and cold carcass weights were recorded.

The bull calves that were kept for beef were grouped together according to calving date with a maximum age difference of 7 days in the case of both breeds. This was done to ensure that over the 21-month growing-out period, steers from both breeds were exposed to similar environmental conditions. These calves were weighed at birth and then once a month until they were removed to the abattoir for marketing at 21 months of age.

The birth weight of J and FxJ bull calves reared for veal and beef differed (P<0.01) being 27.5±1.2 and 31.9±0.8 kg and 26.4±1.0 and 33.4±1.1 kg, respectively (Table 5). Compared to purebred J bull calves crossbred bull calves had significantly higher (P<0.01) average daily gains (ADG) for both veal and beef production systems. This resulted in crossbred FxJ reaching the required live weight for veal production earlier (P<0.01) than purebred J, namely 6.2±0.1 months compared to 7.3±0.1 months of age respectively. The end live weight at marketing of the crossbred steers were 34% higher (P<0.01) than that of the J steers at 21 months of age as demonstrated in Table 5 (433.0±13.3 kg in comparison to 324.4±10.2 kg for J steers).

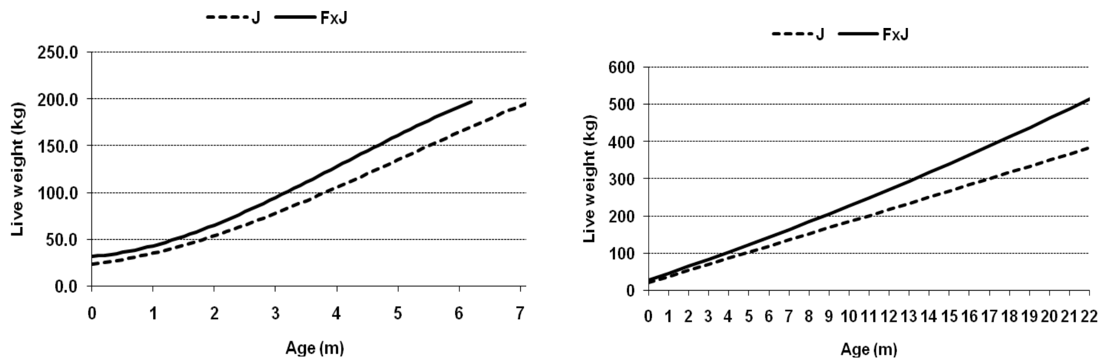
Earlier research by Naude & Armstrong (1967) also demonstrated lower growth rates and efficiency of gain in purebred J steers, compared to beef-Jersey crossbred steers. Crossbreeding J cows with S bulls improved their weight gain by 39%. Reports by Morgan *et al*. (1969) and Barton *et al*. (1994) also demonstrated that the disadvantages of pure J cattle can be greatly reduced by crossbreeding with bulls from beef breeds.

Table 5 The mean ± se growth performances of Jersey (J) and Fleckvieh x Jersey (FxJ) bull calves reared intensively for veal and a pasture-based beef production system (Muller *et al*., 2013)

	Veal production system		Beef production system	
Variables	J	FxJ	J	FxJ
Number of records	22	39	22	25
Birth weight (kg)	27.5^a±1.2	31.9^b±0.8	26.4^a±1.0	33.4^b±1.1
End live weight (kg)	193.6±2.0	194.4±2.5	324.4^a±10.2	433.0^b±13.3
Marketing age (m)	7.27^a±0.12	6.21^b±0.08	21.06±0.08	21.05±0.08
Average daily gain (kg)	0.754^a±0.013	0.865^b±0.017	0.465^a±0.016	0.624^b±0.021
Hot carcass weight (kg)	93.2±1.8	97.9±1.3	161.1^a±7.9	204.4^b±8.1
Dressing-out (%)	0.48^a±0.01	0.50^b±0.01	0.49±0.017	0.47±0.011

^{a,b}Values with different superscripts within production system differ at P<0.01

The earlier age at marketing of FxJ calves for veal and the higher live weights of FxJ steers at the same marketing age compared to J calves and steers are shown in Figure 2 (a) and (b) respectively.



(a) (b)

Figure 2 The live weight of Jersey (J) and Fleckvieh x Jersey (FxJ) bull calves reared as (a) veal and (b) beef to 21 months of age (Muller *et al*., 2013)

As expected FxJ bull calves showed higher growth rates compared to purebred J bull calves that were reared under similar production systems for either veal or beef production. On average, the crossbred bull calves reached the required marketing live weight for veal production, 32 days earlier than J bull calves. The end live weight of FxJ steers was 34% higher than J steers when reared beef production in a partially pasture-based system.

As the Jersey breed is becoming increasingly more popular, especially for pasture-based dairy farming systems in South Africa more research is required to determine the effect of different beef breeds on the beef potential of bull calves which are usually culled soon after birth. This should include the use of indigenous beef breeds that may be more adapted to warmer climates. Any system which includes a beef production option as part of a dairy herd will only be possible if required replacement rate is low as a result of a low culling rate of cows in the herd. Keane (2011) showed that beef production can be increased if beef breeds, i.e. Piedmont and Belgian Blue sires are on Friesian cows. This is achieved through higher meat yields and dressing-out percentages. Similarly, Arpacik *et al*. (1993) demonstrated the potential of Jersey cows in crossbreeding programmes when crossed with Belgian Blue and Chianina as sire lines.

5. Growth and meat quality of Holstein vs. Fleckvieh x Holstein bull calves

In this study, Cloete et al. (2008) compared the growth rate, carcass traits and meat quality of FxH and H) calves reared for veal production. The calves were slaughtered at a commercial abattoir according standard slaughter techniques followed in South Africa.

The primary traits measured in this study included age at slaughter (days), slaughter weight (measured 24 hours prior to slaughtering) and cold carcass weight that was measured after 48 hours in cold storage (4°C). In respect of carcass measurements, the fat depth was measured at two points, namely at the 13th rib 25 mm from the midline and between the 3rd and 4th lumbar vertebrae 25 mm from the midline (Cloete *et al*., 2008). In both cases the measurements were taken on the left side of the carcass.

Meat quality measurements were taken on the *M. longissimus lumborum*. These measurements included pH 45 minutes and 48 hours post mortem on the right side of carcass between the 1st and the 2nd lumbar vertebrae. The *M. longissimus dorsi* muscle of the left side was used for meat quality analyses (Schönfeldt *et al*., 1993). This meat qualities analyses included cooking loss, drip loss, colour and meat tenderness. Meat tenderness was measured with the Warner-Bratzler shear force test using 1.27 cm diameter samples in triplicate as described by Honikel (1998). The results on the growth and carcass characteristics are presented in Table 6.

Table 6 The mean±se of growth and carcass characteristics of Holstein and Fleckvieh x Holstein veal calves reared under an intensive feeding system (Cloete *et al*., 2008)

Trait	Holstein	Fleckviehx Holstein	Significance
Number	14	14	
Slaughter age (days)	141±3	143±2	ns
Slaughter weight (kg)	188.9±2.3	187.9±3.4	ns
Cold carcass weight (kg)	96.9±1.3	95.5±1.5	ns
Fat depth 13th rib (mm)	0.36±0.02	0.39±0.03	ns
Fat depth 3rd/4th lumbar (mm)	0.26±0.05	0.36±0.05	ns
pH_{45}	6.49±0.10	6.66±0.12	*
pH_u	5.38±0.10	5.30±0.10	ns
Cooking loss %	30.2±1.1	30.4±1.3	ns
Drip loss %	1.40±0.04	1.48±0.05	ns
Colour L*	41.3±0.5	41.9±0.6	ns
a*	9.52±0.3	9.79±0.4	ns
b*	9.28±0.4	8.83±0.3	ns
Shear value (N)	39.4± 4.1	42.9± 5.2	ns

* = Significant (P<0.05); ns = Not significant

The slaughter weight and age of FxH and H calves did not differ (P>0.05) because the target was to produce carcasses not exceeding 100 kg (Cloete *et al*., 2008). While pH45 differed (P<0.05), all other carcass characteristics did not differ (P>0.05) between FxH and H veal meat. The fat depth measured at the two different sites also did not differ significantly (P>0.05) between the two genotypes, which indicates that the deposition of subcutaneous fat have not started at this early age, at about 142 days of age (Lawrie, 1998).

Higher pH_{45} value of FxH meat may suggest that these calves experiencing lower stress levels immediately prior to slaughter, which may influence meat quality. Post-mortem pH is determined by the amount of lactic acid produced from glycogen during anaerobic glycolysis. This happens when glycogen is depleted by fatigue or fear (stress) in the animal before slaughter, which will result in a lower initial pH (Lawrie, 1998). This possibility could not be validated, since no measures of stress were recorded while the animals were slaughtered (Cloete *et al*., 2008). This aspect needs further investigation.

Feedlot performance of Holstein bull calves compared to beef breeds

Feed cost is the most significant cost factor in beef production. Feedlots have specific preferences regarding breed or genotype and frame size, based on the monetary outcome. The optimum feeding period varies depending on genotype, frame size and target weight. A preliminary study, using 50 weaner bull calves (approximately 8 to 10 months of age) from Afrikaner, Angus X Bonsmara, Angus x Nguni, Angus x Afrikaner, Bonsmara, Holstein, Nguni and Simmentaler x Afrikaner genotypes were conducted over a 98 days feeding period. The beef breeds and the crosses originated at the Vaalharts Research Station in the Northern Cape, where they were kept on natural grazing. They were transported to ARC Irene six weeks after weaning. The Holsteins were sourced from the dairy herd at ARC Irene. They were hand reared on cow's milk up to the age of between 10 and 12 weeks when they reached a minimum body weight of 60kg and a concentrate intake of 1kg before they were weaned. After weaning they were move to a grass paddock where they were fed 1kg of concentrate and maize silage *ad lib* until they entered this trial.

The daily feed intake and body weights of all bull calves were recorded in real time using the GrowSafe system. This information was used to estimate average daily gain (ADG) and feed conversion ratio (FCR) for individual animals. Feed cost was taken as R3.75 per kg and the price of live weight as R26.32 / kg live-weight. From this information the profit per genotype following the 98 days feeding period was estimated. The performance and profit per genotype is presented in Table 7.

Table 7 Performance and profit per genotype at 98 days on feeding (in order of profit per animal)

Genotype	Number of bull calves	End weight (kg)	ADG (kg)	FCR	Profit/ animal (R)
1. Angus x Bonsmara	9	485	2.06	5.14	R1 424
2. Angus x Nguni	4	470	1.95	5.39	R1 168
3. Bonsmara	9	491	1.99	5.51	R1 105
4. Simmentaler x Afrikaner	3	413	1.71	5.35	R1 054
5. Holstein	4	518	2.30	5.80	R1 020
6. Angus x Afrikaner	2	445	1.84	5.81	R819
7. Afrikaner	10	387	1.63	6.21	R607
8. Nguni	9	374	1.56	6.88	R78

At 98 days of feeding the Angus x Bonsmara was the most profitable to feed (R1 424), followed by the Angus x Nguni (R1 168). The pure Holstein ranked 5th with a profitability of R1 020 per animal. The Holstein had the highest growth rate at 2.30 kg/day, followed by the Angus x Bonsmara at 2.06 kg/day. From these preliminary results it seems that Holstein bull calves do have the potential to produce beef economically. It should however be noted that these results are based on a limited number of animals and that possible differences in meat quality and the effect thereof on price was not considered.

It is recommended that such a study be repeated where breeds such as the Afrikaner and Nguni are evaluated at an older age of 12 to 14 months at start of the test. A study by Linde (2017) indicated that in the Nguni breed, fat may be deposited first and then the genes for growth are upregulated. This may indicate that breeds such as the Afrikaner and Nguni should be feedlot fed at older ages.

Conclusion and Recommendation

Results from all these studies demonstrate the potential for a higher beef income from crossbred veal calves and steers, specifically when compared to pure Jersey calves. Relatively few calving down problems were observed using beef sires on older cows. Studies using local beef breeds are required while optimal feeding programs, marketing age and breed effects on beef quality characteristics need to be established. Using a dual-purpose breed like the Fleckvieh on Holstein cows did not improve beef income compared to Holstein steers although a later age at marketing may result in improved beef income. It is suggested that farmers should use sexed semen on heifers and high genetic merit cows to generate replacement heifers and surplus heifers for sale, while beef sires are used on the rest of the herd for beef production. However rearing too many replacement heifers can be costly because an established market for heifers may be lacking. Similarly using too many beef-on-dairy bulls may result in too few replacement heifers to sustain the dairy herd. This means finding the right balance and planning for the use of sexed semen in an optimal way can be challenging.

In spite of the poor growth rates of crossbred steers and heifers reported in this overview, there appears to be a large potential for beef production when double muscled sires are used on old or low breeding value cows in a dairy herd. In such a case the beef yield of the progeny will be greatly improved, while the milk yield of the cows are not affected. It is recommended that the number of dairy cows used for such crossbreeding should not exceed 20% of the herd, otherwise the genetic improvement of the herd may be compromised as a result of the reduction of the number of replacement heifers from dairy sires.

It is also recommended that crossbred animals should be marketed as beef and not veal. The double muscled crossbred animals from the beef breeds will perform better in feedlots than on a pasture-based system. Arthur (1995) suggested that one of the reasons for better performance under feedlot conditions, is that double muscled animals have smaller digestive tracts, which will imply that they need a more concentrated diet for higher performance.

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