The performance and meat quality of Bonsmara steers raised in a feedlot, on conventional pastures or on organic pastures

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Abstract

The effects of production system (feeding regime and time on feed) on growth performance, yield and economics and the effects of feeding regime, pre-slaughter treatment and electrical stimulation on meat quality were evaluated. Sixty Bonsmara steers were divided into three treatment groups, *viz*. feedlot, organic pasture and conventional pasture feeding. The feedlot and conventional pasture groups received a diet consisting of the same components, while the organic group received a diet with approved organic components. Initial weight, final live weight, warm carcass weight, cold carcass weight, warm and cold dressing percentage, average daily gain (ADG), pH at one and 24 hours *post mortem*, intramuscular fat content of the loin and subcutaneous back fat thickness were measured. The effects of electrical stimulation, feeding regime and pre-slaughter rest (recovery days at the abattoir) on meat tenderness were also investigated. Feedlot cattle had significantly higher final weights, warm and cold carcass weights, warm and cold dressing percentage, ADG, intramuscular fat content and back fat thickness measurements than organic and conventional pasture cattle. Pre-slaughter resting of animals for a week at the abattoir had no effect on meat tenderness, but electrical stimulation showed a significant positive response. Growth and carcass results were used to calculate price and feed margin for the different production systems. Feedlot cattle showed a higher profit than conventional and organic pasture groups, mainly due to faster and more efficient growth. The organic pasture cattle showed higher profit than the conventional pasture cattle as a result of the premium paid for the organically produced meat.

Keywords: Production system, organic, meat quality, profit margins, feedlot, beef cattle
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Introduction

The demand for meat produced in an alternative way to conventional intensive rearing of meat animals has increased globally in recent years (Nilzén *et al*., 2001; Walshe *et al*., 2006, Shongwe *et al*., 2007). One of the main reasons for this phenomenon is the increasing number of food scares (BSE, dioxin pollution and outbreak of foot-and mouth disease) across Europe over recent years (Van Ryssen, 2003a; Walshe *et al*., 2006) which has led to greater awareness of foods that have been produced using chemicals and more recently, free from genetic modification (Walshe *et al*., 2006). Furthermore, the new generation of consumers selects meat products not only according to eating quality and price, but also considers the "ethical quality" involving animal welfare issues and the degree of impact on the environment caused by the production system (Nilzen *et al*., 2001; Kouba, 2003). Apart from their consideration to animal ethics, certain consumers believe that ecologically friendly or non-intensively produced meat (such as organic meat) has more taste and higher nutritional value than conventionally produced meat (Nilzen *et al*., 2001; Muchenje *et al*., 2008). The term "organic" is given to products of farming systems that avoid the use of synthetic fertilisers, pesticides, herbicides, fungicides, veterinarian drugs (antibiotics, growth promoters), synthetic preservatives and additives and irradiation (Kouba, 2003). Despite these perceptions, meat tenderness still remains one of the most important quality attributes when consumers decide to select red meat above other protein sources or distinguish between different meat types (Morgan *et al*., 1991; Brooks *et al*., 2000; Thompson, 2002). Variation in meat quality is influenced by various pre-slaughter factors such as nutrition, breed, age, environment and post-slaughter conditions such as rate of rigor development, length of ageing time and method of hanging (Troy, 1995) and is therefore not limited to the effect of a single factor.

While an interplay of many factors affects meat quality and consumer preferences, the diet fed to the animal is one of the most important production factors (Kerry *et al.*, 2000) and is the key to the successful utilisation of any production system irrespective of consumer preferences. Supporters of organic animal production argue that organic livestock production systems should contribute to a more balanced overall farm production, better food safety, improved animal welfare and better support to rural development, nature conservation and a lower environmental load (Hermansen, 2003). Opponents to organic animal production argue that organic farming leads to lower animal production as a result of lower stocking rates and lower output per unit land, meaning higher production costs (Van Ryssen, 2003b). In contrast, advocates for conventional, intensive feedlot production of beef claim that cattle in the feedlot have a higher average daily gain (ADG) than those fed on pasture and that animals can reach their target weight sooner with resulting higher production turnover (Fernandez & Woodward, 1999). They believe that producers gain the most in economic terms as long as they follow conventional methods including the use of growth promoting substances, antibiotics, deworming practices and creep feeding.

Since the organic food sector now occupies a prominent role within the retail environment, it is important to understand whether or not there is scientific support for organic food production, which has been primarily driven by the consumer perception (Walshe *et al.*, 2006). In this study the interaction of production system and pre-slaughter treatment of animals with consideration to ecologically friendly and animal welfare practices were investigated for animal performance and economics of production. The production system and pre-slaughter scenario were extended to slaughter and post slaughter practices to investigate the combined effects on meat quality**.**

Materials and Methods

Sixty Bonsmara steers weighing between 204 and 300 kg, aged seven to eight months were divided into three groups (A, B and C) so that the mean weight and variation for the three groups were the same (Figure 1). The cattle in Group A were subjected to intensive feeding in pens (20 square metres per animal) and received a diet consisting of concentrate and hay. The concentrate contained genetically modified ingredients, urea, flavophospholipol, Rumensin® and other synthetic ingredients (Table 1). The hay was fed

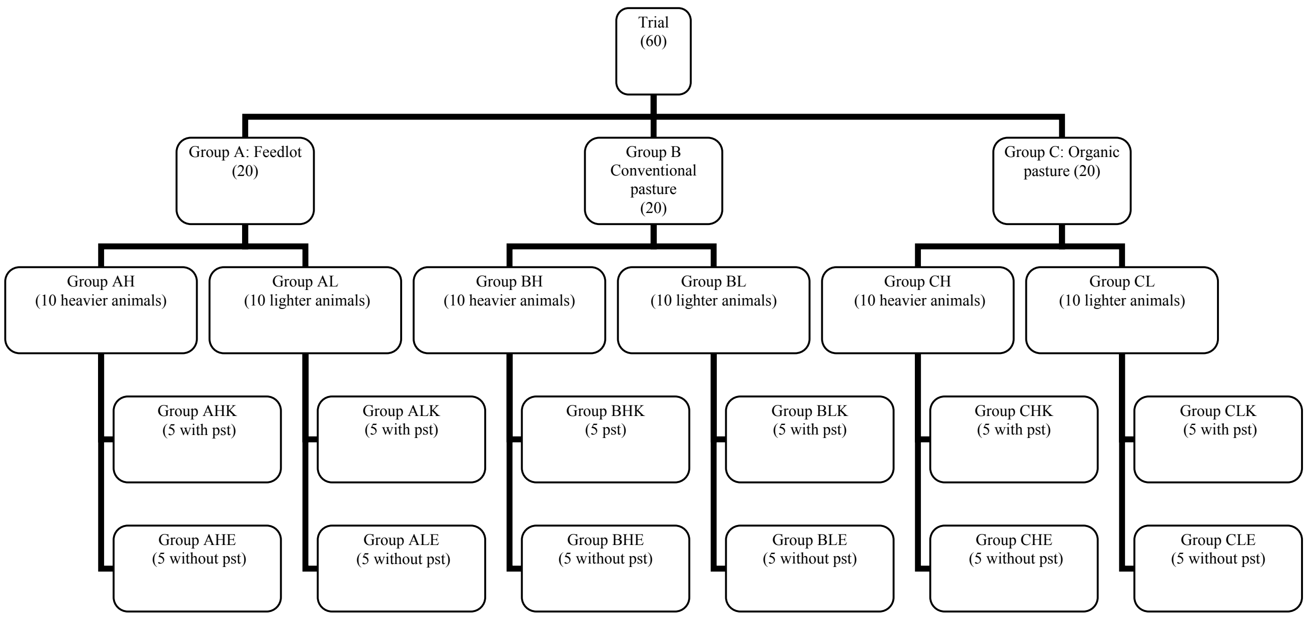

Figure 1 Experimental design (note: pst stands for pre-slaughter treatment).

Table 1 Physical and chemical composition of concentrate rations

Raw materials	Conventional concentrate (%)	Organic concentrate (%)
White maize	24.90	15.94
Maize gluten 20	9.54	10.00
Hominy chop	25.00	25.00
Sunflower hulls	5.00	10.00
Pollard	16.00	16.00
Coconut oil cake	1.00	-
Palm oil cake	2.50	-
Soya oil cake 47	1.00	-
Calcium carbonate	2.54	2.52
Salt	0.75	0.75
Urea	1.49	-
Molasses	10.00	10.00
Premix A	0.25	0.25
Flaveco ®	0.02	-
Rumensin ®	0.015	-
Prime gluten 64	-	7.50
Full fat soya 36	-	2.05

Chemical analysis ("as is" basis)

	Conventional concentrate		Organic concentrate	
	Formulation	Actual analysis	Formulation	Actual analysis
Protein	15.00	18.59	15.00	19.34
Fat	4.27	4.53	4.60	4.19
Ash	6.73	7.27	6.77	8.48
NDF	22.02	28.84	24.17	28.03
ADF	8.92	9.68	11.13	9.48
Moisture	12.26	11.81	11.85	11.84
Fibre	7.11	10.58	9.22	9.18
Calcium	1.00	1.02	1.00	1.27
Phosphate	0.47	0.51	0.48	0.52
Urea	1.50	0.72	0.00	0.19
Potassium	0.87	0.38	0.89	0.42

ADF = acid detergent fibre; NDF = neutral detergent fibre.
Flaveco contains 4% flavophospholipol; Rumensin contains 20% monensin.

separate from the concentrate. Cattle in group B received the same concentrate as Group A, but were kept on natural pasture at a stocking rate of more than 10 hectares per cattle unit. Animals in Group A and B were implanted at commencement of the trial with an anabolic growth promoter containing 200 mg progesterone and 20 mg estradiolbensoate. Cattle in Group C received an organic concentrate and were kept on pasture where rearing conditions complied with the guidelines of organic animal farming set by ECOCERT, an international control and certification organisation whose activities are governed accordingly by the public authorities and legislation (ECOCERT, 2008). ECOCERT is accredited for structure and procedures by COFRAC (French committee for accreditation), in accordance with guide standard ISO 65 (EN 45011), which requires independence, competence and impartiality. In particular, animals in the organic group were not given supplements with synthetically produced ingredients or genetically modified feed ingredients and no antibiotics were used (Table 1). Pasture for Groups B and C and the hay cut for Group A consisted of a mixture of *Digitaria eriantha* and *Eragrostis curvula.* The two concentrate diets were nutritionally very similar (Table 1) and were presented *ad libitum* to all treatment groups as explained in Table 2.

Table 2 Stratification of diets between different treatment groups

	Group A	Group B	Group C
Organic concentrate	No	No	Yes
Conventional concentrate	Yes	Yes	No
Natural hay	Yes, cut and presented on cafeteria-basis.	Yes. Grazing.	Yes. Grazing.

Since production systems in South Africa focus on uniform carcass fatness at slaughter, each group of animals was divided into a heavy (H; presumed closer to finish) and light (L; to be fed for a longer period) subgroup of 10 animals each on day 63 of the trial (see coding of groups in Figure 1). H subgroups were presumed closer to slaughter, while L groups needed to add more weight so that the subgroups reached a marketable carcass weight (close to or above 200 kg) and uniform condition (fatness). The heavy feedlot (AH) and conventional pasture (BH) subgroups received 68 g of the beta-agonist, Zilmax®, per ton concentrate from day 63 until day 82 when the Zilmax was withdrawn according to regulations. Similarly, L subgroups of the feedlot (AL) and conventional pasture (BL) treatments received 68 g of Zilmax® per ton concentrate from day 98 until day 117 when the Zilmax was withdrawn for the final two days on feed. In order to address animal welfare and product quality in the trial, five animals were randomly selected from subgroups of 10 animals and transported to the abattoir a week prior to slaughter (day 78 and 113 for H and L groups respectively) to decrease stress levels and to heal bruises caused by transport from the farm to the abattoir (denoted by K; Figure 1). The remaining five animals of each subgroup were transported to the abattoir on the day of slaughter (day 85 and 120 for to H and L groups respectively; denoted by E). All animals that were rested (denoted by K) and were fed in a feedlot next to the abattoir according to their original main treatments.

Animals were weighed in a fasted state (fasted from feed for 18 hours) at the start and at the end of the trial to limit variation in gut fill. The animals were slaughtered and dressed according to commercial practices. The effect of low voltage electrical stimulation on meat quality was investigated by stimulating (160 V, four seconds on, three seconds off, for 90 seconds and a pulse of five milli-seconds on and 70 milli-seconds off) all carcasses of the second slaughter group (day 120), while carcasses of the first slaughter group did not receive any electrical stimulation (day 85). Carcasses were split and chilled at 2 ± 1 °C, before sampling the following day. Muscle pH of each carcass was determined one hour and 24 hours *post mortem* in the *M. longissimus thoracis* (LT) between the 9th and 10th rib. Back fat thickness was measured between the 9th and the 10th thoracic vertebrae at a point 2.5 cm from the midline of the carcass. A portion of the LT was removed between the 9th to 10th rib for total lipid analyses according to the method of Folch *et al.* (1957). Total extractable intramuscular fat was determined gravimetrically from the extracted fat and expressed as the weight (g) of fat per 100 g muscle tissue, and was expressed as a percentage.

For meat tenderness measurement, the *M. longissimus lumborum* (LL) of the wing rib cut (11th to 13th rib) was removed from one side of the carcass, vacuum sealed, aged for seven days at 3 °C and frozen at -20 °C. Frozen samples were cut into three 30 mm steaks and thawed at 3 °C for 18 hours before preparation. Thawing loss was determined. Thawed steaks were prepared according to an oven-broiling method using direct heat (AMSA, 1978). An electric oven was set on "broil" 10 minutes prior to preparation (260 °C). Steaks were placed on an oven pan on a rack to allow meat juices to drain during cooking and placed in the pre-heated oven 9 cm below the heat source. The steaks were cooked to an internal temperature of 35 °C, then turned over and finished to 70 °C. Raw and cooked weight and cooking time were recorded and total cooking loss calculated. Steaks were cooled down at room temperature for at least two to three hours before measuring shear force. Eight cylindrical samples (12.5 mm core diameter) of each sample were cored parallel to the grain of the meat, and sheared perpendicular to the fibre direction using a Warner Bratzler shear device mounted on an Universal Instron apparatus (cross head speed = 200 mm/minute; one shear in the centre of each core). The reported value in kg represents the average of the peak force measurements of each sample.

Average values for starting weight, ADG, feed conversion ratio (FCR), final live weight processing cost of animals, carcass selling price, income from the skin and tripe, dressing percentage, cost of slaughter, and percentage of interest were used to calculate financial data. In the calculation of intake of whole feed ration and FCR the intake of concentrate and fodder was taken into consideration. The cost of 12.4 c per kg on an "as is" basis was used for natural grass (Bezuidenhout, 2007: H.D. Bezuidenhout, Pers. Comm., P.O. Box 10934, Centurion 0046, South Africa). The price of concentrates was determined by the feed supplier (Nutri-Feeds, P.O. Box 22733, Bloemfontein 9313, South Africa). Zilmax®-prices were taken into account in the calculations for the feedlot and conventional pasture groups. The purchase price at the start of the trial was the price the cattle could be sold for at that stage (R 11.30/kg for weaner calves). Processing costs were calculated as the combined costs of deworming (R 7.20 per animal) and the growth stimulant (R 14.00 per animal) for the conventional pasture (B) and feedlot (A) treatments. The difference in selling price between conventional and organic carcasses was the premium the producer received. Economy in the finishing of cattle was determined according to the following formula:

Net margin = feed margin + price margin – interest – marketing costs + income from hide and tripe.

Price margin was defined as the difference between purchase price of the live animal (weaner) and the carcass selling price of the same animal. Feed margin was defined as the net value of the final carcass determined as the difference between production costs and marketing income from the carcass (Van der Merwe, 2007: H.J. van der Merwe, Pers. Comm., Department of Animal-, Wildlife-, and Grassland Sciences, University of the Free State, P.O. Box 339, Bloemfontein 9300, South Africa). Comparisons were made between the three production systems in terms of net margin and price per kilogram carcass produced.

The data were subjected to analysis of variance with production system, days on feed and pre-slaughter treatment as main effects for growth and carcass characteristics, while production system, electrical stimulation and pre-slaughter treatment were tested as main effects for meat quality characteristics (ANOVA) (NCSS, 2007). Means separation was achieved by Tukey-Kramer multiple comparison test at the 5% level (NCSS, 2007). No statistical analyses were done on financial data.

Results and Discussion

Production system affected all carcass characteristics significantly (Table 3). Feedlot cattle gained weight at 0.5 kg/day faster, were slaughtered at 56 kg heavier and produced carcasses of 40 kg heavier with a 2% advantage in dressing percentage compared to the conventional pasture group ($P < 0.001$). Despite a slight advantage of the conventional pasture group over the organic pasture group, no significant differences were recorded for these traits. As a consequence of the higher growth rate and higher slaughter weight, the feedlot carcasses were significantly fatter, and measured almost 3 mm thicker back fat thickness ($P < 0.001$) and 0.66% more ($P < 0.05$) intramuscular fat than conventional pasture carcasses that did not differ significantly from organic pasture carcasses (Table 3). These differences are in agreement with Keane & Allen (1998) and Sami *et al.* (2004) and can be attributed mainly to higher levels of nutrition for feedlot animals. In contrast, Padre *et al.* (2006) and Razminowics *et al.* (2006) found no significant differences ($P > 0.05$) in intramuscular fat content between different production systems, while Walshe *et al.* (2006) found organically produced beef to have significantly ($P < 0.05$) higher intramuscular fat content compared to conventionally produced beef. However, due to confidentiality reasons the diet of the organic treatment was not known and could have been richer in energy than the conventional diet.

The extension of the growth phase of lighter animals in an attempt to produce uniform carcass weights and conditions proved to be successful as no significant differences ($P > 0.05$) were observed in the animal performance parameters between the groups fed 85 and 120 days (Table 3). Keeping the animals at the abattoir for the week prior to slaughter to recover from possible bruises and exhaustion had no significant ($P > 0.05$) advantage with regard to production traits over animals delivered and slaughtered on the same day.

It may be argued that the days on feed could have confounded the effect of electrical stimulation and that the proper design would have been to apply the stimulation treatment at both slaughter groups. However, the abattoir operation did not allow for this option and it should be considered that the difference in age between the slaughter groups was relatively small (35 days). In addition, the carcass characteristics in terms of weight and fatness within production system for the two slaughter points were the same and therefore no effect of variation in days on feed on meat quality was expected. This is confirmed by Strydom *et al.* (2008) who reported differences up to 70 days on feed had no significant effect ($P > 0.05$) on tenderness of aged meat, even when large differences in carcass weight and fatness occurred.

South African Journal of Animal Science 2008, 38 (4)

Table 3 The effects of production system, days on feed and pre-slaughter treatment on animal performance characteristics

	Production system				Days on feed			Pre-slaughter treatment		
	Feedlot	Pasture	Organic	Sign.	85 Days	120 Days	Sign.	One week before slaughter	Same day as slaughter	Sign
Start weight (kg)	258 ± 24	255 ± 26	254 ± 24	NS	271 [b] ± 19.23	240 [a] ± 19	***	254 ± 25	258 ± 24	NS
Final weight (kg)	416 [b] ± 28	359 [a] ± 37	346 [a] ± 23	***	376 ± 36	371 ± 48	NS	366 ± 42	381 ± 41	NS
Warm carcass weight (kg)	257 [b] ± 18	215 [a] ± 22	203 [a] ± 13	***	227 ± 25	223 ± 33	NS	222 ± 29	228 ± 29	NS
Cold carcass weight (kg)	249 [b] ± 17	209 [a] ± 21	197 [a] ± 12	***	220 ± 24	217 ± 32	NS	215 ± 28	221 ± 28	NS
Warm dress-out percentage	61.94 [b] ± 3.55	59.94 [a] ± 1.39	58.87 [a] ± 1.82	***	60.39 ± 3.23	60.12 ± 2.14	NS	60.88 ± 1.99	59.83 ± 3.27	NS
Cold dress-out percentage	60.09 [b] ± 3.44	58.15 [a] ± 1.35	57.10 [a] ± 1.76	***	58.58 ± 3.13	58.31 ± 2.08	NS	58.86 ± 1.93	58.03 ± 3.17	NS
Average daily gain (ADG) (kg/day)	1.52 [b] ± 0.26	1.04 [a] ± 0.32	0.91 [a] ± 0.31	***	1.25 ± 0.41	1.07 ± 0.36	NS	1.10 ± 0.42	1.22 ± 0.36	NS
Thickness of fat (mm)	7.08 [b] ± 2.77	4.15 [a] ± 1.92	4.09 [a] ± 1.53	***	5.23 ± 1.99	4.98 ± 3.00	NS	5.08 ± 3.04	5.13 ± 1.94	NS
Intramuscular fat (%)	2.26 [b] ± 0.99	1.60 [a] ± 0.49	1.86 [a] ± 0.57	*	1.89 ± 0.85	1.93 ± 0.66	NS	1.92 ± 0.84	1.90 ± 0.68	NS

NS = not significant; * = P <0.05; ** = P <0.01; *** = P <0.001.
[a,b] Means with different superscripts within a row and treatment differ significantly.

Electrical stimulation significantly (P <0.001) advanced glycolysis as measured by pH one hour *post mortem* (Table 4). The rest of the rigor development (conversion of muscle to meat) could not be followed since pH was not recorded further, apart from the final pH at 24 hours *post mortem* that was not significantly (P >0.05) influenced by production system, pre-slaughter treatment or electrical stimulation.

No significant differences (P >0.05) were observed in meat tenderness between different production systems or pre-slaughter treatment groups (Table 4). Electrical stimulation improved the shear force tenderness by more than 1 kg over non-stimulated carcasses (P <0.001). However, the effect was more pronounced for the conventional pasture treatment (2.5 kg) and organic treatment (1.2 kg) and not significant for the feedlot treatment (0.5 kg) (Interaction: P <0.001, Figure 2). According to Figure 2, pasture reared animals had the least tender meat when no stimulation was applied, but the most tender meat when carcasses were stimulated. Feedlot and organic meat did not differ significantly with or without electrical stimulation. No further tests (biochemical, histological) were performed to verify the reasons for differences among treatments and interactions. However, with reference to other studies possible explanations can be given of factors that acted together or against one another to result in the values record. Beta-agonists are known to increase meat toughness (Schroeder *et al*., 2003; Avendano-Reyes *et al*., 2006) mainly due to an increase in calpastatin activity and a decrease in μ-calpain activity (Geesink *et al*., 1993; Simmons *et al*., 1997) causing a lower rate of *post mortem* ageing. It is also widely accepted that electrical stimulation improves meat tenderness by preventing excessive shortening (Swatland, 1993) when carcasses chill too quickly and also by physical disruption of the myofbrillar matrix (Ho *et al*., 1997) and the acceleration of proteolysis (Uytterhaegen *et al*., 1992). Strydom *et al.* (1998) have demonstrated that electrical stimulation interacted positively with beta-agonists by contributing more to tenderness of beta-agonist treated loin muscle than to control muscles. Hearnshaw *et al.* (1998) and Ferguson *et al.* (2000) explained this phenomenon with Brahman cattle where the negative effect of higher calpastatin activity was overcome by effective electrical stimulation that enhanced the activity of calpains in carcasses with *Bos indicus* content, thereby cancelling out the negative effect of higher calpastatin activity, which is similar to the situation with beta-agonists. Considering the effect of beta-agonists and cold shortening in the absence of electrical stimulation and the effects of electrical stimulation discussed, it is difficult to distinguish between the proportional effects of these factors in the present trial. However, it could be considered that the conventional pasture group had tougher meat than both the feedlot and organic pasture groups due to the combined effect of beta-agonist and cold shortening in the absence of stimulation. It is possible that the conventional pasture group was tougher than the feedlot group despite the fact that both received Zilmax due to smaller leaner carcass of the pasture group and hence the faster chilling rate compared to the feedlot group. On the other hand, the organic pasture group mirrored the leanness and carcass size of its conventional counterpart and was equally susceptible to cold shortening. Therefore, the feedlot group, due to the beta-agonist, and the organic pasture group due to cold shortening could have ended up with similar tenderness measurements. All three production systems benefited from electrical stimulation with the conventional pasture group gaining the most in tenderness probably due to the combined effect of prevention of cold shortening and the enhancement of the proteolytic process as described by Hearnshaw *et al.* (1998) and Ferguson *et al.* (2000). The feedlot carcasses gained the least from stimulation probably due to the fast pH decline caused by stimulation while muscle temperature was still high. Since the feedlot animals were fatter than the pasture groups, their carcasses would have chilled at a lower rate, resulting in the onset of rigor (pH = 6.0) at muscle temperature in the high 30 degrees when stimulation was applied. According to Devine *et al.* (1999) this is detrimental to tenderness and rate of ageing. High temperature combined with low pH values could result into *rigor* contracture (termed heat shortening) which also has a concurrent reduction in ageing potential leading to less tender meat both at *rigor mortis* and when fully aged.

In general, the shear values of more than 5 kg for un-stimulated carcasses and between 4 and 5 kg for stimulated carcasses did not compare very favourably with threshold values for consumer acceptability, according to Shackelford *et al.* (1991). They reported threshold values of 4.6 kg and 3.9 kg for "retail" and "food service" beef, respectively (samples were prepared according to the same specifications as those used by ARC-Irene Sensory laboratory).

Table 4 The effects of feeding regime, pre-slaughter treatment and electrical stimulation on pH, shear force resistance, cooking loss and thawing loss of beef

	Feeding regime				Pre-slaughter treatment			Electrical stimulation		
	Feedlot	Pasture	Organic	Sign.	One week before slaughter	Same day as slaughter	Sign.	Non-stimulated	Stimulated	Sign.
pH1	6.05 ± 0.40	6.23 ± 0.38	6.10 ± 0.38	NS	6.21 ± 0.40	6.05 ± 0.37	NS	6.41 [b] ± 0.29	5.85 [a] ± 0.26	***
pH24	5.78 ± 0.10	5.83 ± 0.12	5.81 ± 0.10	NS	5.80 ± 0.11	5.82 ± 0.11	NS	5.83 ± 0.11	5.79 ± 0.11	NS
Shear force (kg)	5.22 ± 0.65	5.47 ± 1.55	4.99 ± 0.98	NS	5.31 ± 1.04	5.14 ± 1.21	NS	5.93 [b] ± 1.04	4.53 [a] ± 0.68	***
Total cooking loss (%)	21.71 ± 1.50	21.08 ± 1.50	20.95 ± 1.16	NS	21.05 ± 1.48	21.44 ± 1.33	NS	21.41 ± 1.58	21.08 ± 1.23	NS
Thawing loss (%)	2.47 ± 0.99	2.94 ± 0.89	2.46 ± 0.91	NS	3.08 [b] ± 0.83	2.17 [a] ± 0.85	***	2.81 ± 0.96	2.43 ± 0.90	NS

NS = not significant * = P <0.05; ** = P <0.01; *** = P <0.001.
[a,b] Means with different superscripts within a row and treatment differ significantly.

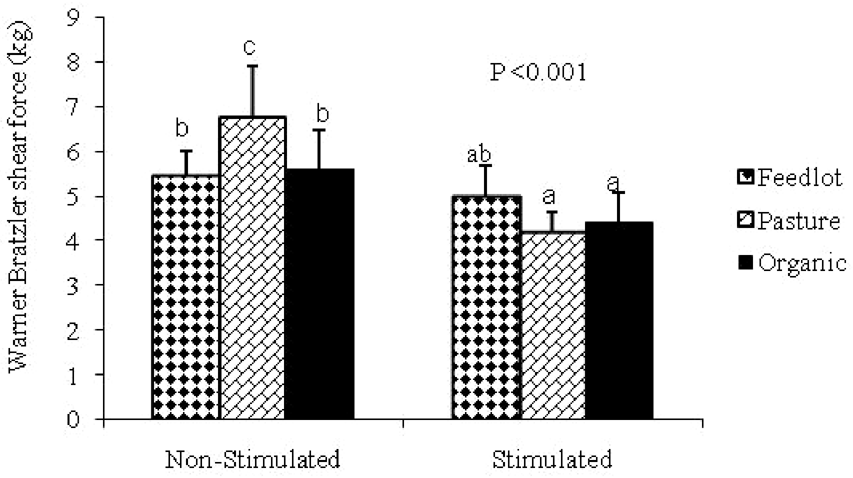

Figure 2 Interaction between production system and electrical stimulation with regard to tenderness. (Means with different superscripts differ significantly (P <0.001)).

Table 5 Calculation of price and feed margin, and profit or loss

	Group A : Feedlot	Group B : conventional veld	Group C : organic veld
Start weight (kg)	258	255	254
Final live weight (kg)	416	359	346
Average daily gain (kg/day)	1.52	1.04	0.91
Feed conversion ratio	6.56	9.08	10.06
Buying price (R/kg live weight)	11.30	11.30	11.30
Feed cost (R/ton)	1502.84	1502.84	1672.21
Processing (R)	34.10	34.10	19.20
Selling price (R/kg carcass)	22.50	22.50	24.50
Income: skin and tripe (R)	320.00	320.00	320.00
Dress out percentage (A2)	61.94	59.94	58.87
Abattoir costs (R)	300.00	300.00	300.00
Interest percentage	17.00	17.00	17.00
Intake of whole feed ration (kg)	1037.00	953.76	924.61
Days fed	102.5	102.5	102.5
Price margin	**(-361.62)**	**(-357.84)**	**(-132.42)**
Feed margin	**1653.16**	**865.88**	**688.01**
Total margin	**1291.54**	**508.04**	**555.59**
Plus income from skin and tripe	320.00	320.00	320.00
Minus abattoir costs	300.00	300.00	300.00
Minus interest	193.12	187.44	190.23
Equals profit (loss)/animal	**1118.42**	**340.60**	**385.36**

Pre-slaughter treatment had no significant (P >0.05) effect on tenderness (Table 4). Newson *et al.* (1999) showed that animals arriving on the day before slaughter or were fasted for two days prior to slaughter had tougher meat than those arriving days before slaughter and stayed on feed. In the first two scenarios, the stress of feed withdrawal and standing overnight had a draining effect on glycogen, while in the present trial the muscle glycogen levels were probably less affected due to shorter feed withdrawal and less stress.

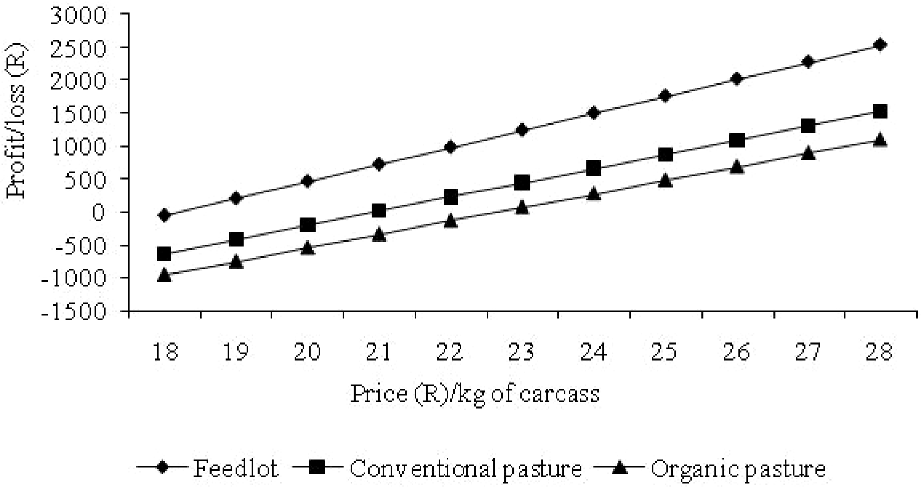

Figure 3 The effect of price per kg carcass on profit/loss of different production systems.

Table 6 The effect of production system on carcass price per kg and between different production systems

	Break-even price (R)	Price per kg to break-even with feedlot at R 22.50/kg (R)	Price per kg to break-even with conventional pasture at R 22.50/kg (R)	Price per kg to break-even with organic pasture at R 24.50/kg (R)
Feedlot	18.16	-	19.48	19.66
Conventional veld	20.92	26.10	-	22.71
Organic veld	22.61	28.10	24.28	-

No significant differences (P >0.05) were observed in total cooking loss and thawing loss between different production system groups (Table 4).

The economical evaluation is presented in Table 5. The data for both the feeding periods (85 and 120 days) were combined under each production system. If diets of higher protein and energy content were used, higher growth figures for profit could have been obtained, but a conservative approach was selected to prevent possible metabolic disorders such as rumen acidosis and laminitis. Cattle fed in the feedlot made the best profit due to a lower FCR. The R 2.00/kg premium on organic meat gave the organic pasture animals an economic advantage over conventional pasture animals.

The effect of different carcass selling prices on the net economical effect was investigated and is presented in Figure 3. The profit for feedlot cattle remained higher than both pasture groups, while the conventional pasture group did better than the organic pasture group if the organic premium is not taken into account. This tendency remained the same, independent of the carcass price, because feedlot animals gained weight faster and more efficiently than pasture animals.

To summarize the effect of the production system used the general break-even point of each system on carcass price (R/kg), as well as the break-even points between production systems were compared (Table 6). Feedlot animals needed the lowest carcass price to break even followed by conventional pasture animals and organic pasture animals. It is interesting to note that the organic group had to reach a price of R 28.10/kg to compete with meat from the feedlot, when feedlot meat was sold at R 22.50/kg, which is a premium required of R 5.60/kg. Conventional pasture carcasses had to sell for R 3.60/kg more than feedlot carcasses to break even with feedlot carcasses and organic carcasses had to sell at a premium of R 1.78/kg to compete with conventional pasture carcasses. The reverse side of the equation was equally interesting. The feedlot had an advantage of R 2.76 at a fixed price of R 22.50 for conventional pasture carcasses and an advantage of R 4.45 at a fixed price of R 24.50 (with premium) over organic carcasses.

Conclusions

Cattle raised in the feedlot grew faster and produced larger carcasses than cattle raised on conventional and organic pastures. Given the specific production procedures for the three production systems (types of diets and supplements) and the criteria used to calculate profitability in this trial, the faster, efficient growth is the main reason why feedlot grown cattle are more economical than organic and conventional pasture production, despite a realistic premium used to calculate profitability of organic production. A higher premium has to be negotiated, if conventional pasture or organic producers want to compete with feedlot producers.

Beta-agonist and cold shortening were the two main reasons for meat tenderness variation among production systems when no electrical stimulation was applied to carcasses. However, electrical stimulation proved to be very effective in improving meat tenderness in general and alleviating the variation among groups. Despite the improvement, electrical stimulation combined with the seven day *post mortem* ageing was not sufficient to produce a final product of acceptable eating quality under the production scenarios of this trial. Provided that pre-slaughter stress elements such as food withdrawal, handling and transport are not extreme animals rested for a number of days pre-slaughter with proper feed and water have no advantage over animals arriving just before slaughter with regard to production or meat quality characteristics.

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