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Influence of Feeding Systems on the Eating Quality of Beef

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Contents

INFLUENCE OF FEEDING SYSTEMS ON THE EATING QUALITY OF BEEF

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CONTENTS

SUMMARY

The objective was to determine pre-slaughter factors which may enhance the eating quality of beef and to assist the Irish beef production chain to exploit these factors to produce beef of higher quality and increased consumer acceptability. The effects of pre-slaughter growth rate, high energy diets, feed type and age at slaughter on beef quality were examined.

Contrary to reports in the scientific literature, growth rate before slaughter did not alter the tenderness of beef steaks. There was no evidence of increased breakdown of proteins during storage of meat from cattle with different growth rates.

Steers offered high energy rations for eight weeks before slaughter produced beef of similar eating quality to those with similar carcass weights on a lower energy diet. On the other hand, beef from animals offered *ad libitum* concentrates or forage diets had 4.4% and 2.3% intramuscular fat respectively. Although tenderness scores for the concentrate fed were higher than those of the forage fed group, they were not statistically different. Carcass weights were lower for forage (330 kg) than for concentrate fed cattle (371 kg).

A whiter fat cover on beef carcasses was obtained by feeding maize silage. This type of carcass is particularly sought after in some lucrative continental markets. Maize silage had no detrimental effects on the eating quality of the beef.

Diet of animals also affected the retail display life of fresh beef. Retail cuts from forage fed cattle had greater colour and lipid stability than beef from concentrate fed animals.

The effect of age at slaughter was examined in 24 and 30 month old cattle. Beef from the older animals tended to be darker in colour and tougher.

Overall, pre-slaughter diet influenced the colour of the fat, the type of fatty acids and level of intramuscular fat in the lean, as well as the shelf-life and colour stability of retail meat cuts. The diets studied did not alter the flavour or tenderness of beef.

INTRODUCTION

It is imperative in today's competitive market for Irish beef to be of the highest quality possible. Production systems affect beef quality and it is therefore vital that the influence of these systems on meat quality is determined in an Irish context. The variability of beef quality stems from many sources, including breed, sex, age at slaughter, nutrition and environment. The type of muscle and carcass composition are also important. Much has been published on the influence of breed and sex of animal on meat quality. Two control points, which could be readily manipulated but are not yet fully understood, are feeding regime and age at slaughter. Most research has concentrated on changes in carcass composition and not on changes in meat quality. Recent evidence (Wood *et al.*, 1995) suggests that the rate of growth and muscle protein turnover can impact strongly on meat quality but the precise mechanisms remain unclear. It has been suggested recently (Beever *et al.*, 1992) that high growth rates at slaughter result in more tender beef due to *in vivo* activation of enzymes which remain active after slaughter to degrade the meat protein structure. Growth rates in cattle can be readily manipulated and could be an effective method of enhancing tenderness.

High energy diets increase the flavour, juiciness and tenderness of beef (May *et al.*, 1992). This may be a consequence of increased growth rates, increased fat cover (delayed chilling), increased intramuscular fat (marbling) and increased proportions of n-6 fatty acids derived from linoleic acid, which would affect flavour. Type of feed can effect meat quality. Wood *et al.*, (1995) reported that grain fed animals produced more tender meat with increased flavour intensity and juiciness, whiter fat colour and improved muscle colour stability, compared to grass fed cattle.

Tenderness decreases as animals age through an increase in collagen mediated toughness (Shorthose and Harris, 1990). Generally, animals are slaughtered between 18 and 30 months of age in Ireland. It is important to identify the effect of age within this period on meat quality attributes.

This project examined four production factors: (a) growth rates at slaughter (b) duration of high energy diet (c) type of feed, and (d) animal age at slaughter; and three meat quality attributes; tenderness, flavour and colour. The reader is referred to the companion report entitled: "Production factor effects on the eating quality of beef" (Moloney and Troy, 2001).

General methods

Cattle were captive bolt stunned and exsanguinated conventionally at the research abattoir or at a commercial beef processing plant. Excised striploins (*M. longissimus dorsi)* were aged at 0°C to +2°C up to 14 days post-slaughter.

Steaks 2.5 cm thick, were cut after 2, 7 and 14 days ageing for Warner-Bratzler shear force (WBSF) measurements. Steaks were cut after 14 days for colour measurements, wrapped in an oxygen permeable PVC wrap and allowed to bloom at 4°C for 3h.

Meat colour and eating quality were measured at The National Food Centre. The lightness 'L' , redness 'a' and yellowness 'b' colour coordinates of lean meat were measured using a HunterLab Ultrascan XE colorimeter.

Tenderness measurements were taken by standard protocols. Shear force was measured using an Instron Model No. 1140 with a Warner Bratzler blade attachment. Sensory analysis was carried out using the protocols of the American Meat Science Association (AMSA, 1978). Steaks were grilled to an internal temperature of 70°C and judged by trained taste panellists. Panellists were asked to assess the samples on a hedonic scale of 1-8 as follows:

Tenderness	scale 1-8	1=extremely tough	8=extremely tender
Juiciness	scale 1-8	1=extremely dry	8=extremely juicy
Flavour	scale 1-5	1=very poor	5=very good
Chewiness	scale 1-6	1= not chewy	6= extremely chewy
Texture	scale 1-6	1= very poor	6= extremely good
Overall acceptability	**scale 1-6**	**1 = not acceptable**	**6 = extremely acceptable**

Sensory analysis being performed

At University College Cork, meat colour stability and lipid oxidation were examined using two forms of packaging; over-wrapping (aerobic) using oxygen permeable PVC film and modified atmosphere packaging (MAP) 80% O_2: 20% CO_2 . Packaged meat was held under retail display conditions (4°C under 616 lux fluorescent lighting) for 17 days. Colour was determined by measuring the 'redness' or Hunter 'a' values using a Minolta Chromameter, and the 'brownness' or metmyoglobin accumulation using a Perkin-Elmer (Lamda 2) spectrophotometer and by visual assessment. The extent of lipid oxidation, α-tocopherol (vitamin E) concentration and fatty acid analysis was also measured.

Pre-slaughter growth rates and meat quality

The hypothesis tested in this experiment was that an increase in energy consumption prior to slaughter will increase meat tenderness independent of a change in fat deposition. Studies in the United States demonstrated a positive correlation between the duration of high energy feeding prior to slaughter and tenderness of meat of feedlot cattle. Carcasses of animals fed a high-energy ration were in general, heavier and fatter than similar animals fed a lower energy ration. A positive correlation between marbling score and tenderness was frequently seen in these studies. Similar studies in pigs concluded that high growth rate increased meat tenderness independent of an increase in fat deposition. Since consumer preference is for lean meat, it is important to establish whether tenderness can be improved without an effect on fatness in beef cattle.

The effect of different pre-slaughter growth rates on meat quality was investigated. Sixty Friesian steers were group-housed and offered grass silage *ad libitum* and 3.5 kg concentrates per animal daily for 6 months before the experiment began. The animals were then weighed, assigned to one of 5 groups in a randomised block bodyweight (BW) design. The 5 groups were then randomly assigned to one of 4 dietary treatments, or for slaughter at the beginning of the experiment (data from this group not shown). Sufficient concentrates and hay (100 g/kg total diet) to achieve a mean target growth rate of 0.72 kg/day, and based on individual BW, were offered to all animals. Three concentrate supply patterns were imposed to achieve target growths of 0.72 kg/day continuously (CONT), 0.36 kg/day for the first 8 weeks and 1.08 kg/day for the final 8 weeks (LOW-HIGH), or 1.08 kg/day for the first 8 weeks and 0.36 from the final 8 weeks (HIGH-LOW). Animals were offered their individual daily concentrate allowances in two equal feeds, were weighed at 2 week intervals and feed allowances were adjusted at 4 week intervals, or as appropriate to each pattern. After slaughter, carcass measurements were made, the pistola hind quarter was dissected into fat, lean and bone and the tenderness of the striploin was measured instrumentally and by a trained taste panel. Biochemical measurements of meat quality were also performed.

Selected variables are summarised in Table 1. The pattern of concentrate supply did not affect carcass weight, fat score or kidney/channel fat weight. Animals offered the LOW-HIGH concentrate pattern had a similar pistola hindquarter composition to CONT animals but were leaner than animals offered HIGH-LOW or PULSE concentrate patterns.

Shear force was not significantly different between treatments nor were sensory tenderness scores. The breakdown of meat proteins by proteolytic enzymes was not different between treatments indicating that cattle slaughtered at high growth rates (1.08 kg/day) did not have a higher proteolytic breakdown of proteins than those slaughtered at normal (0.72 kg/day) or low growth rates (0.36 kg/day).

Table 1: Quality attributes of steaks from Friesian cattle with different rates of growth for 16 weeks before slaughter

	Pattern of concentrate consumption			
	Continuous	Low-High	High-Low	Significance
Shear force (kg) 2d	5.96	7.42	6.22	NS
Shear force (kg) 7d	4.13	5.54	4.43	NS
Shear force (kg) 14d	3.88	4.63	4.33	NS
Tenderness[a] 2d	3.65	3.62	4.47	NS
Tenderness[a] 7d	5.59	5.05	5.36	NS
Chewiness[b] 14d	2.69	3.37	3.08	*
Flavour[c] 14d	3.84	3.78	3.51	*

[a] 1= extremely tough, 8= extremely tender;
[b] 1= not chewy, 6= extremely chewy;
[c] 1= very poor, 6= extremely good:
NS = not significant
* = significant effect

In conclusion, the data do not support the hypothesis that pre-slaughter growth rate increases tenderness but suggest that concentrate supply pattern can influence body composition of finishing cattle.

High energy diets and beef palatability

To qualify for premium payments, beef cattle are held until a fixed age or for a fixed period. Flat rate feeding of supplementary concentrates during finishing is not necessarily appropriate as some animals could be over-fat by the premium eligibility date. Accordingly, feeding silage initially and saving the concentrates for feeding at a high level towards the end of the finishing period may avoid over-fatness and save in the quantity of concentrates fed. The objective of this study was to document the changes in the eating quality of beef due to relevant modifications of the standard system.

Charolais x Friesian steers (n=28) aged about 19 months and averaging 568 kg liveweight were assigned to two groups; group 1 was fed silage plus 6.35 kg/day concentrates to slaughter at 126 days, group 2 was fed silage only for 35 days, adjustment for 21 days, and then concentrates *ad libitum* until 756 kg were consumed (approximately 10 weeks). Animals were slaughtered at a commercial facility and striploin steaks were removed for quality assessment. Mean carcass weight did not differ significantly between treatments.

Data are summarised in Table 2. Mean growth rate in the final 8 weeks before slaughter was 733 and 1332 g/day for the silage and concentrates and concentrates *ad libitum* groups, respectively. There was no difference in striploin tenderness between the two treatments at 2, 7 or 14d ageing as assessed by Warner Bratzler shear force or by the taste panel. There was no effect of diet on the colour or on the chemical composition of striploin. The marbling fat content was similar, 2.9% and 2.1% in restricted and *ad libitum* concentrates, respectively.

A further objective was to determine the effect of the high energy diet on beef colour and quality when meat was held under retail display conditions, either overwrapped (aerobic) or modified atmosphere packaged (MAP). Colour analysis showed there was no difference in Hunter “a” values or proportion of metmyoglobin between the two dietary groups.

It was concluded that there was no benefit in terms of eating quality in offering steers a high energy ration for eight weeks before slaughter under the conditions of this study.

Feeding grass or concentrates and eating quality of meat

Feed costs are a major proportion of total variable costs in beef systems and grazed grass is often the cheapest feedstuff in temperate climates. However, the value of beef from grass-finished cattle is often discounted compared with concentrate-fed beef because of perceived differences in meat quality. While

Table 2: Growth rates of Charolais X Friesian cattle finished on restricted or *ad libitum* concentrate supplementation and effect on the carcass quality and eating quality of the meat

Variable		Restricted concentrates	*Ad libitum* concentrates	s.e.d.	Significance
Concentrate dry matter					
Intake (kg/animal)		662	670		
Silage dry matter					
Intake (kg/animal)		486	449		
Pre-slaughter growth (g/day)					
(final 8 weeks)		733	1332	86.4	P<0.01
Carcass weight (kg)		356	364	7.2	NS
Fat score		4.1	4.2	0.09	NS
Kidney / channel fat (kg)		11.9	11.1	0.77	NS
Longissimus dorsi					
Fat (g/kg)		29	21	4.7	P= 0.08
Protein (g/kg)		219	223	2.3	P= 0.1
pH (48 h)		5.51	5.52	0.025	NS
Hunter "L"		42.7	42.9	0.55	NS
Hunter "a"		19.2	19.2	0.55	NS
Hunter "b"		14.5	14.6	0.48	NS
Drip loss (g/kg)		23	24	3.8	NS
Shear force (N)	- 2 days	53.4	52.5	5.43	NS
	- 7 days	40.8	40.0	3.80	NS
	- 14 days	38.1	35.9	3.36	NS
Sensory analysis (14 days)					
Tenderness		5.8	5.8	0.29	NS
Juiciness		5.4	5.0	0.24	P= 0.1
Flavour		4.1	4.0	0.13	NS
Firmness		4.9	5.0	0.24	NS
Texture		3.8	3.8	0.14	NS
Chewiness		3.1	3.1	0.17	NS
Acceptability		4.0	3.9	0.19	NS

there is evidence, particularly from North American beef production systems, that concentrate-fed animals produce more tender and better flavoured meat than forage-fed animals, dietary effects in many of these experiments are confounded by differences in animal age or carcass weight at slaughter. When both feeds are offered *ad libitum*, carcass growth of concentrate-fed cattle is often higher relative to animals fed grazed grass or other forages. Thus, concentrate-fed animals have heavier and fatter carcasses than forage-fed animals when grown for a constant time period or may be younger when grown to a specific bodyweight or back fat thickness. Carcass weight, back fat thickness, age at slaughter and pre-slaughter growth rate have all been shown to alter meat tenderness and flavour.

The objective was to measure the quality of meat from cattle finished on grass alone, on concentrates offered *ad libitum* (expressing full genetic potential for growth) or on combinations of both. Sixty six continental (Limousin and Charolais) crossbred steers (567 kg) were assigned to one of six diets: 1) 18 kg grass dry matter (DM), 2) 18 kg grass DM grass and 2.5 kg concentrate, 3) 18 kg grass DM and 5 kg concentrate, 4) 6 kg grass DM and 5 kg concentrate, 5) 12 kg grass DM and 2.5 kg concentrate or 6) concentrates *ad libitum*. Animals were slaughtered after an average of 95 days. Samples of striploin (*M. longissimus dorsi*) were collected at the 8-9th rib interface for sensory analysis and other assessments of quality following 2, 7, or 14d ageing.

Carcass weight gain averaged 360, 631, 727, 617, 551 and 809 g/day for treatments 1 to 6 respectively. Animals offered grass only had lower carcass weight gain than all other treatments while animals offered concentrates *ad libitum* had highest carcass weight gain. There was no difference between diets for colour, Warner Bratzler shear force (WBSF) or any sensory attribute of the striploin. WBSF was negatively correlated with carcass growth rate (-0.31; $P<0.05$) but only a small proportion of the variation in meat quality between animals could be attributed to diet pre-slaughter or carcass fatness. Furthermore, intramuscular or marbling fat was significantly higher ($P<0.001$) in concentrate fed beef (4.4%) than grass fed beef (2.3%).

Beef quality differed depending on the type of packaging used. For the two extreme diets (grass only and concentrates *ad libitum*) there was no significant difference in colour of overwrapped meat. However for MAP meat, surface redness was significantly higher (greatest Hunter 'a' values) in the group fed grass only. When the other four diets were compared to these two extreme groups there was no significant difference in colour with either form of packaging. When visual assessment of MAP packaged meat was carried out, the group fed grass only was most preferred while the group fed concentrates *ad libitum* was least preferred. Meat lipid oxidation, which is a measure of rancidity, was highest for the all concentrate diet compared to other dietary groups under both forms of packaging. Lipid oxidation was much higher for the MAP meat compared to the overwrapped meat.

It was concluded that high carcass growth can be achieved on a supplemented grass diet without a deleterious effect on meat quality relative to high concentrate diets and when held under retail display conditions, beef colour stability depends on the packaging used.

Feeding grass silage or maize silage and fat colour and composition

Components of the diet can affect fat colour. Grass, which contains carotenoids, can lead to yellow fat on carcasses. Finishing animals on maize silage or diets not based on grass silage can produce carcasses with significantly whiter fat, a trait sought after and demanded in some important European markets.

Forty five crossbred heifers were offered *ad libitum* grass silage (GS), a mixture of 50:50 grass silage:maize silage (GS:MS) or maize silage (MS) *ad libitum* for approximately six months before slaughter at a commercial facility. Samples of subcutaneous fat and striploin steaks were removed for colour and lean quality assessment. In a separate experiment heifers (n=36) were given a diet of either grass silage *ad libitum* plus concentrates or straw *ad libitum* plus concentrates for 4 months before slaughter at a commercial facility. The effects of each of these diets on fat colour, lipid oxidation, fatty acid composition, flavour components and beef quality were assessed after slaughter.

Animals finished on 100% MS had whiter cover fat than when grass silage was included in the diet (Table 3). This was likely due to the exclusion of carotenes from the diet and demonstrates that it is possible to manipulate carcass for colour to satisfy the requirements of specific markets. The same affect can also be achieved by feeding cattle a diet of straw *ad libitum* plus concentrates for four months before slaughter. Animals finished on this diet had significantly whiter cover fat than those finished on grass silage plus concentrates for the same period. In both of the above experiments the eating quality of the resultant beef was unaffected by the type of feed. Tenderness, flavour and colour of 14 days aged lean beef (Hunter "L", "a" and "b" values) were the same in each experiment regardless of the diet of the animal.

When meat was held under retail display conditions, either overwrapped or MAP packed, there was no significant difference between silages in Hunter 'a' values (redness). However, when metmyoglobin accumulation (brownness) was determined, the aerobic packed samples showed significant difference in the proportion of metmyoglobin between the three dietary groups. The GS group had lower proportions of metmyoglobin than the MS:GS group and the

Table 3: The effect of substituting increasing amounts of maize silage for grass silage on carcass fat colour in beef heifers

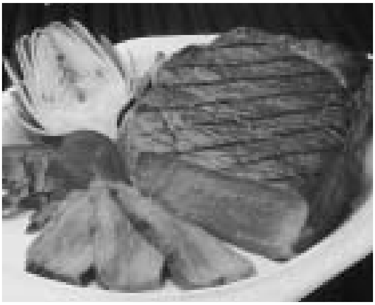
	Maize silage (g dry matter /kg)				
	0	500	1000	s.e.d.	Significance
Subcutaneous fat colour					
Visual assessment	2.60	2.37	1.30	0.209	L***G*
Hunter "b" value	17.0	17.0	13.5	0.53	L**G**
Kidney + channel fat colour					
Hunter "b" value	27.0	24.6	20.7	1.25	L**

*L and Q are linear and quadratic effects of maize silage inclusion respectively

MS groups ($P<0.05$). In MAP packed meat displayed for 12 and 17 days, the MS fed group had the highest proportion of metmyoglobin. In terms of overall colour, the visual panel most preferred the GS group and least preferred the MS group. When oxidative stability was assessed between the three dietary groups, the MS fed group had highest TBARS numbers while the GS group had lowest TBARS numbers. The MS:GS group had TBARS numbers which were intermediary. This trend was observed in both packaging types. Vitamin E (α-tocopherol) was 2.08μg/g, 2.95μg/g and 3.84μg/g in the MS, MS:GS and GS groups respectively.

Free choice profiling showed differences in the flavour of beef from grass silage or maize silage. Analysis of variance (ANOVA) did not clearly distinguish between flavour volatiles in beef from different feeding treatments. However, principle component analysis (PCA) clearly distinguished between meat from the different groups. Substituting maize silage for grass silage did not change the amount of volatiles but did induce changes in the profiles of individual compounds. In particular, differences were observed in the distribution of certain aldehydes, alkanes and alkylbenzenes. Differences in the balance of individual compounds, particularly the more odour-active aldehydes, could cause changes in flavour when maize silage is substituted for grass silage.

It was concluded that beef from grass silage fed animals had better overall quality in terms of colour, lipid oxidation and vitamin E levels than beef from maize silage fed animals under retail display conditions.



High quality beef meal

Concentrate composition and type of forage and beef quality

The objective was to determine the effect of different forage (extensive and restricted-fermentation grass silage and zero-grazed perennial ryegrass) and concentrate (starchy and fibrous) on the quality of beef grown at similar rates.

Striploins from seventy-five Friesian steers fed 5 rations of different composition (diet E- extensively fermented silage and concentrate, diet R- restricted fermentation silage and concentrate, diet S- starch-based concentrate and wheat straw, diet F- fibrous concentrate and wheat straw and diet G- zero-grazed perennial ryegrass and concentrate) each were analysed for composition, shear force, sensory parameters, colour stability, lipid oxidation, α-tocopherol and flavour volatile composition. Ultimate pH (pHu), drip and cook loss were also measured.

pHu, drip and cook losses, as well as shear force values and the colour of the lean at 14 days ageing, did not differ amongst diet groups. Differences existed in the yellowness of the fat cover, with fat from animals on diet G being significantly more yellow than all of the other diets except diet E. When colour analysis was carried out under retail display conditions using meat in overwrap or MAP packaging, clear trends were observed for the aerobically packed samples while trends were not as apparent in the MAP samples until the latter days of the study. In the aerobically packed samples there was a difference in Hunter "a" values between the five dietary groups ($P<0.001$). Mean Hunter "a" values decreased in the following order: E (9.98), R (8.54), F (7.33), G (7.19), S (7.06) over the 17 days. The E group also had the lowest proportion of metmyoglobin over the 17 days and mean levels increased in the order: E (29.68), G (36.87), R (38.50), S (41.72), F (45.81). The E group was ranked highest by a sensory panel while the R group was ranked as second best. Under aerobic packaging there was a difference in TBARS numbers between the five dietary groups ($P<0.001$). The S and F groups displayed highest levels of oxidation compared to the R, E and G groups which did not differ significantly from each other. α-tocopherol decreased in the order: E (7.78μg/g), R (5.72μg/g). F (4.51μg/g), RYE (4.18μg/g), SC (3.26μg/g).

It was concluded that beef from forage-fed animals had greater colour and lipid stability than beef from concentrate-fed animals under retail display conditions. Beef from an extensively fermented silage had better colour stability than beef from a restricted fermented silage but did not differ in levels of lipid oxidation. When beef from starch concentrate and fibrous concentrate feeds were compared, there was no difference in overall quality.

Whole crop wheat or grass silage-based rations and fat colour

For producing good quality beef at low cost, whole crop wheat-based diets are easily accessible to Irish beef producers and could be a cost effective way to satisfy carcass fat specifications in lucrative markets.

The objective was to investigate if conventional grass silage feeding could be substituted by a more economic diet based on whole crop wheat without a detrimental effect on meat quality. Forty-five heifers were randomly assigned to three dietary treatments. The diets were (1) grass silage, the conventional diet in Ireland, (2) early whole crop wheat silage, the production of which gives greater yields than grass, and (3) urea-treated late whole wheat silage, the production of which gives even greater yields than either of the previous crops. All diets were supplemented with 3kg of concentrates per day. After 4 months, the animals were slaughtered in the conventional manner. The pH of the striploin (*M. longissimus dorsi*) was measured 48 h post mortem. Samples were taken after 2, 7 and 14 days ageing at 4°C for WBSF and cook loss, sensory analysis at 14 days, compositional analysis at 2 days, lean meat colour at 2 and 14 days ageing and subcutaneous fat colour at 2 days ageing.

The conventional grass silage diet resulted in yellower fat colour ($p<0.001$) than the early wheat silage-based diet and the late whole wheat silage-based diet treated with urea ($p<0.001$). The early whole wheat silage diet also showed yellower fat ($p<0.01$) than the late whole wheat silage treated with urea. The grass silage produced redder fat ($p<0.05$) than either of the wheat silage diets. There was no difference between the wheat silage diets in fat redness. There were no differences amongst treatments in any of the other quality attributes measured. It was concluded that beef producers can substitute either of the wheat silage diets for grass silage, as they have no detrimental effect on the eating quality of the meat. Furthermore, it may be

Feed can affect meat quality

of greater advantage to feed cattle with untreated late crop wheat as it is a more economical feed and it produces meat with whiter subcutaneous fat, which is preferred in some European countries.

Age at slaughter and meat colour and tenderness

The majority of Irish calves are spring-born. The most widely practised system of beef production is steers, slaughtered at approximately two years of age following a period of indoor finishing on rations based on grass silage and concentrates. Finishing steers at 30 months of age following a grazing period can reduce production costs. Changes in age, diet and pre-slaughter environment accompany this change in production system so there is need for information on their combined effects on the eating quality of beef.

Twenty four steers which had just completed their second grazing season were blocked to two treatments and housed for their second winter. Twelve steers were offered grass silage *ad libitum* and 5.4 kg concentrates until slaughter in April at about 25 months of age. The other twelve were offered

Table 4: Carcass and striploin characteristics of 24 and 30 month old cattle finished indoors in Spring or off pasture in Autumn

Variable	Spring 24 months old	Autumn 30 months old	s.e.d.	Significance
Pre-slaughter growth (g/day)				
(Final 18 weeks)	666	675	61.4	P<0.01
Carcass weight (kg)	342	376	6.6	P<0.01
Fat score	4.0	3.6	0.17	P<0.05
Kidney / channel fat	13.0	11.3	0.91	P=0.1
Striploin				
Fat (g/kg)	23	28	5.4	NS
Protein (g/kg)	229	223	2.5	P<0.05
pH (48 h)	5.49	5.48	0.018	NS
Hunter "L"	36.9	35.6	0.56	P<0.05
Hunter "a"	16.4	15.8	0.30	NP= 0.06
Hunter "b"	9.6	9.1	0.21	P<0.05
Drip loss (g/kg)	38	30	3.6	P<0.05
Shear force (kg) - 2 days	4.3	8.6	0.98	P<0.01
- 7 days	3.6	5.2	0.57	P<0.05
- 14 days	3.4	4.5	0.50	P= 0.07
Sensory analysis (14 days)				
Tenderness	5.5	4.9	0.46	NS
Juiciness	4.5	4.1	0.34	NS
Flavour	4.0	3.8	0.17	NS
Firmness	4.8	5.2	0.33	NS
Texture	3.6	3.3	0.18	NS
Chewiness	2.8	3.2	0.25	NS
Acceptability	3.8	3.5	0.21	NS

Tenderness, 1 = extremely tough, 8 extremely tender;
Juiciness, 1 = extremely dry, 8 = extremely juicy;
Flavour, 1 = very poor, 6 = extremely good;
Firmness, 1 = extremely mushy, 8 extremely firm;
Texture, 1 = very poor, 6 = extremely good;
Chewiness, 1 = not chewy, 6 = extremely chewy;
Acceptability, 1 = not acceptable, 6 = extremely acceptable

unsupplemented grass silage *ad libitum* and then grazed on a perennial ryegrass sward until slaughter in September at about 30 months of age. Data for this experiment are summarised in Table 4.

Mean growth rate in the final 18 weeks for steers slaughtered at 24 or 30 months of age was 666 and 673 g/day, respectively. Steers finished indoors at 24 months had lighter but fatter carcasses than those finished off pasture at 30 months but there was no difference in intramuscular fat concentration. Steers finished off pasture had darker (lower Hunter "L") and less red (lower Hunter "a") striploins. Warner Bratzler shear force of 14 day-aged striploins tended to be higher for pasture-finished steers but panellists considered striploins from both treatments to be equally tender.

It was concluded that modifying a standard 2 year-old production system to 30 months resulted in darker meat but had no effect on the eating quality of beef.

▲ *Animal eating feed supplement*

CONCLUSIONS:

- Increasing the pre-slaughter growth rate did not improve any measurement of tenderness, thus rejecting the hypothesis that pre-slaughter growth rate *per se* increases tenderness.
- There was no benefit in eating quality in offering steers a high energy ration for eight weeks before slaughter.
- High carcass growth can be achieved on a supplemented grass diet without a deleterious effect on meat quality relative to a concentrate based diet.
- When held under retail display conditions, the colour and lipid oxidation of beef depends on the form of packaging used.
- Substitution of grass silage with maize silage in the diet of finishing heifers gave whiter fat with no effect on tenderness or flavour of lean beef. When held under retail display conditions, colour and oxidative stability was best for heifers fed grass silage and worst for the heifers fed maize silage.
- Beef fed an extensively fermented silage had better colour stability than beef fed a restricted fermented silage but did not differ significantly in levels of lipid oxidation. Feeding a starch concentrate or fibrous concentrate made no difference to overall quality.
- Substituting grass silage diets for early whole crop wheat silage or urea-treated late whole wheat silage diets had no detrimental effect on the eating quality of the meat.
- Modifying a standard 2 year-old production system to a 30 month system gave darker meat but had no effect on the eating quality.

RECOMMENDATIONS TO INDUSTRY

Some on-farm factors affect the eating quality of beef. For instance, it is widely accepted that animals stressed prior to slaughter produce abnormal beef. Equally, cattle fed high-energy diets generally produce highly marbled beef, resulting in a more succulent product.

However, cattle fed to different growth rates gave beef of similar tenderness. In general the greatest influence on tenderness is related to how the carcass is handled just after slaughter (Troy, 1999).

Results from this project demonstrate that feeding systems can influence fat colour and so impact on markets where fat colour is an issue. Feed has little effect on fresh muscle colour but can influence colour stability. Grass based diets in general result in beef with greater colour stability than maize or wheat silage. There is also an opportunity to improve the colour stability of beef by dietary supplementation with antioxidants such as vitamin E.

There is evidence too that diet influences the flavour of beef. Flavour compounds manifest themselves upon cooking and flavour of cooked meat relates to the composition of sugars and fatty acids present in the meat. Although few data are available on an Irish beef production environment, it is known that the type of feed alters the sugar and fatty acid composition of meat.

Finally, feed can alter the nutritional status of beef from a human health point of view by altering the amount and type of fatty acids. Generally, grass based diets beneficially increase the ratio of polyunsaturated to saturated fatty acids in beef, increase the omega-3 (n-3) fatty acids and increase the level of conjugated linolenic acid (CLA). These findings suggest that the fatty acid composition of beef can be improved from a human health perspective by inclusion of grass in the diet (Moloney and Troy, 2001).

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