SENSORY COMPARISON OF MUSCLES (LD, GM, ST) FROM CHAROLAIS AND LIMOUSIN BULLS FED ON PASTURE, GRASS SILAGE AND CONCENTRATE SUPPLEMENTATION

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Abstract-The objective of this study was to compare three bovine muscles; m. longissimus dorsi (LD), m. gluteus medius (GM) and m. semitendinosus (ST) for meat quality using sensory analysis. Two methods were used for assessing sensory characteristics of beef, the first was traditional 8-point hedonic scaling and the second, a method which combines ranking descriptive analysis (RDA) data with hedonic data (sensory acceptance testing). Sensory analysis was conducted on 158 samples from Charolais and Limousin sired suckler bred bulls (n=100). Animals were fed on 7 different diets and slaughtered at 19 months of age. Steaks were cooked and served to a 10-member sensory panel in individual sensory booths. Data was analysed using *Analysis of variance* partial least squares regression (APLSR). Results showed that the LD muscle was positively correlated for appearance, tenderness, flavour, juiciness, texture and acceptability and negatively correlated for firmness, while ST was negatively correlated for tenderness, flavour, juiciness, texture, acceptability and positively correlated for firmness. GM was positively correlated for tenderness, texture and acceptability. The diet with the most negative effect on meat quality was the grazed grass plus ad libitum concentrates. However, the diet of ad libitum concentrates only had a positive effect on meat quality.

Key Words: **Analysis of variance, Meat quality, Sensory analysis**

I. INTRODUCTION

The most significant aspect of meat quality in beef is sensory or eating quality. The two most important intrinsic beef quality attributes are flavour and tenderness in nearly all beef consuming countries [1] with juiciness and texture following closely behind. Beef farming in Ireland is predominantly pasture-based with steers produced at >24 months of age [2]. However, recently producers are exploiting the biological advantages of bulls. At present, there is a need to develop novel cost-effective systems of producing bulls that provide meat which is regarded as acceptable to the consumer. It is therefore, desirable to investigate the role of grazing in the production of these young bulls.

The objective of this study was to assess the eating quality of beef samples from Charolais and Limousin sired suckler bred bulls which were slaughtered at 19 months of age. Many factors affect beef quality. This study investigated the effect of breed, diet and muscle location. Three muscles were compared; m. longissimus dorsi (LD), m. gluteus medius (GM) and m. semitendinosus (ST). Bulls were fed on seven different diets which consisted of various combinations of grazed grass, grass silage and concentrates. The work presented here shows the differences observed in meat quality between breeds, diets and muscle types.

II. MATERIALS AND METHODS

2.1 Animals, diets and sampling

Spring-born, late maturing Limousin and Charolais cross bred bulls (n=100) were used in this study. For the first indoor winter period (140 days) all animals were offered high nutritive value grass silage ad libitum plus supplementary concentrate. At the end of the winter indoor period, animals were blocked on weight and age, and from within block, randomly assigned to one of seven

production systems for a duration of 200 days 1) grazed grass (unsupplemented) (GG) for 200 days, 2) GG for 100 days followed by GG plus 0.50 dietary intake as concentrate for 100 days, 3) GG for 100 days followed by ad libitum (AL) concentrates offered indoors for 100 days, 4) GG plus 0.50 dietary intake as concentrate for 200 days 5) GG plus 0.50 dietary intake as concentrate for 100 days followed by AL for 100 days 6) GG plus 0.50 dietary intake as concentrate for 100 days followed by AL concentrate 2 (with fish oil added) for 100 days and 7) AL offered indoors for 200 days. Concentrate two is a ruminally protected fish oil feed. All animals were slaughtered at the end of the study (19 months of age). Slaughtering took place in a commercial abattoir. Samples were then obtained, aged and frozen before meat quality analysis.

2.2 Sensory analysis

Steaks (2.54 cm thick) were defrosted at 4˚C for 24 hours and cooked at 200˚C in an electric Zanussi oven to a core temperature of 72˚C. Samples were served immediately to a panel of ten naïve assessors. Each panellist rated the sensory qualities of these samples which were generated during the course of the project according to the methodology of the American Meat Science Association [3, 4]. The experiment was conducted in panel booths, which conformed to International Standards [5]. The panellists rated five sensory qualities on a scale (8-point hedonic) from 1-8 for tenderness (3-5 chews) where 1=extremely tough and 8=extremely tender, overall flavour where 1=very poor and 8=extremely good, overall firmness where 1=extremely mushy and 8=extremely firm, overall texture where 1=very poor and 8=extremely good and overall acceptability where 1=not acceptable and 8=extremely acceptable. In a different session, sensory acceptance testing was conducted using ten naïve assessors [6, 7]. A 10 cm continuous line scale was used to quantify hedonic attributes (appearance, flavour, texture and acceptability). Liking of appearance, flavour and texture were rated from extremely dislike to extremely like and overall acceptability was rated from extremely unacceptable to extremely acceptable. These assessors then participated in ranking descriptive analysis (RDA) [8] using a consensus list of sensory descriptors (firmness, juiciness, toughness, meat-flavour intensity and off-flavour) in which was also measured on a 10 cm line scale. Firmness was rated from extremely soft to extremely firm; juiciness, from not juicy to extremely juicy; toughness, from extremely tender to extremely tough; meat flavour intensity and off-flavour, from none to extreme. All samples were presented in duplicate [9].

2.3 Statistical analysis

Data was analyzed using *Analysis of variance* partial least squares regression (APLSR). The software programme was the Unscrambler X 10.3.

III. RESULTS AND DISCUSSION

Data analysed from the 8-point hedonic scale (Table 1) shows that the Limousin were positively ($P \leq 0.05$) correlated for texture whereas the Charolais were negatively ($P \leq 0.05$) correlated for texture. The LD muscle was found to be positively ($P \leq 0.05$) correlated for tenderness, overall flavour, overall texture and overall acceptability and negatively ($P \leq 0.05$) correlated for overall firmness. GM was positively ($P \leq 0.05$) correlated for tenderness, overall texture and overall acceptability whereas the ST muscle was negatively ($P \leq 0.05$) correlated for tenderness, overall flavour, overall texture and overall acceptability and positively ($P \leq 0.05$) correlated for overall firmness.

In relation to the different dietary groups, GG + AL was negatively ($P \leq 0.05$) correlated for tenderness while GG+0.50+AL concentrate two (fish oil) showed to be positively ($P \leq 0.05$) correlated for overall flavour. AL concentrate was positively ($P \leq 0.05$) correlated for overall texture and overall acceptability. This data indicates that the diet of AL concentrates for 200 days has the most positive effect on meat quality.

Table 1. Mean scores and standard deviations of the sensory attributes of three muscles (LD, GM, ST) from Charolais and Limousin cross-bred bulls fed on 7 diets using an 8-point hedonic scale.

Table 1. Breed/Muscle type/Diet	Tenderness	Flavour	Firmness	Texture	Acceptability
LIMOUSIN	4.78±1.8^{ns}	5.08±1.5^{ns}	5.08±1.5^{ns}	4.97±1.5*	5.02±1.5^{ns}
CHAROLAIS	4.60±1.8^{ns}	4.97±1.5^{ns}	5.15±1.4^{ns}	4.74±1.5^{-}*	4.89±1.5^{ns}
Longissimus dorsi	4.77±1.7*	5.12±1.4***	5.03±1.4^{-}*	4.91±1.5*	5.03±1.5**
Gluteus medius	4.74±1.8*	4.96±1.5^{ns}	5.13±1.5^{ns}	5.08±1.5***	5.07±1.5*
Semitendinosus	4.24±1.8^{-}***	4.64±1.6^{-}***	5.43±1.5***	4.35±1.6^{-}***	4.50±1.6^{-}***
1.GG	4.77±1.7^{ns}	4.97±1.5^{ns}	5.20±1.4^{ns}	4.93±1.5^{ns}	5.00±1.5^{ns}
2.GG,GG+0.50	4.79±1.7^{ns}	5.16±1.4^{ns}	4.97±1.5^{ns}	4.88±1.5^{ns}	5.05±1.5^{ns}
3.GG+AL	4.50±1.9^{-}*	4.86±1.5^{ns}	5.29±1.5^{ns}	4.64±1.6^{ns}	4.77±1.6^{ns}
4.GG+0.50	4.67±1.7^{ns}	5.20±1.3^{ns}	5.04±1.4^{ns}	4.89±1.6^{ns}	5.02±1.4^{ns}
5.GG+0.50,AL	4.55±1.5^{ns}	5.10±1.4^{ns}	5.07±1.4^{ns}	4.83±1.5^{ns}	4.98±1.4^{ns}
6.GG+0.50,AL2	4.85±1.8^{ns}	4.75±1.5*	4.94±1.4^{ns}	4.81±1.5^{ns}	4.98±1.6^{ns}
7.AD LIBITUM	4.69±1.7^{ns}	5.06±1.5^{ns}	5.14±1.5^{ns}	4.93±1.5*	4.98±1.5*

Table 1. P-Values are from the estimated regression coefficients from ANOVA-Partial least squares regression (APLSR) for sensory data acquired using the method of AMSA (1995; 2005). The sign dictates whether the correlation is positively (e.g. **) or negatively correlated (e.g. $^{-}$**).

GG=grazed grass
AL=ad libitum

Table 2 and Table 3. Mean scores and standard deviations of the sensory attributes of three muscles (LD, GM, ST) from Charolais and Limousin cross-bred bulls fed on 7 diets using a 10cm line scale (RDA+SAT).

Significance of regression coefficients:

NS =not significant
*95% significance, P≤0.05
**99% significance, P≤0.01
***99.9% significance, P≤0.001

Table 2. Breed/Muscle type/Diet	Appearance	Flavour	Texture	Acceptability
LIMOUSIN	6.18±1.9^{ns}	5.50±2.1^{ns}	5.25±2.2^{ns}	5.46±2.0^{ns}
CHAROLAIS	6.18±1.9^{ns}	5.49±2.2^{ns}	5.18±2.3^{ns}	5.58±3.8^{ns}
Longissimus dorsi	6.35±1.8**	5.72±2.0***	5.51±2.2***	5.86±3.6***
Gluteus medius	5.72±2.1^{ns}	5.59±2.1^{ns}	4.75±2.3^{ns}	5.05±2.1^{ns}
Semitendinosus	5.85±2.1^{ns}	4.68±2.3^{-}**	4.38±2.4^{-}***	4.65±2.2^{-}**
1.GG	6.47±1.8^{ns}	5.43±2.2^{ns}	5.68±2.1^{ns}	5.66±1.9^{ns}
2.GG,GG+0.50	6.51±1.6^{ns}	5.82±2.0^{ns}	5.49±2.2^{ns}	5.64±2.0^{ns}
3.GG+AL	5.97±2.1^{-}*	5.08±2.2^{-}*	4.71±2.3^{-}***	4.97±2.1^{-}*
4.GG+0.50	6.23±1.9^{ns}	5.71±1.9^{ns}	5.49±2.4^{ns}	5.73±1.8^{ns}
5.GG+0.50,AL	6.37±1.6^{ns}	5.70±1.7^{ns}	5.31±1.9^{ns}	5.53±1.4^{ns}
6.GG+0.50,AL2	6.36±1.8^{ns}	5.81±1.9^{ns}	5.54±2.0^{ns}	6.67±7.7^{ns}
7.AD LIBITUM	6.10±1.9^{ns}	5.73±2.2^{ns}	5.31±2.3^{ns}	5.62±2.1^{ns}

Table 2 and 3. P-Values are from the estimated regression coefficients from ANOVA-Partial least squares regression (APLSR).
The sign dictates whether the correlation is positively (e.g. **) or negatively correlated (e.g. $^{-}$**).

Significance of regression coefficients:
NS =not significant
*95% significance, P≤0.05
**99% significance, P≤0.01
***99.9% significance, P≤0.001

Table 3. Breed/Muscle type/Diet	Firmness	Juiciness	Toughness	Meat flavour intensity	Off-flavour
LIMOUSIN	5.58±2.2^{ns}	3.71±2.3^{ns}	4.99±2.5^{ns}	4.78±2.2^{ns}	1.41±2.0^{ns}
CHAROLAIS	5.65±2.2^{ns}	3.36±2.1^{ns}	5.09±2.5^{ns}	4.79±2.3^{ns}	1.31±1.9^{ns}
Longissimus dorsi	5.18±2.2^{-}***	3.73±2.2**	4.66±2.4^{-}***	4.87±2.2^{ns}	1.31±1.9^{ns}
Gluteus medius	6.37±2.0^{ns}	3.10±2.3^{ns}	5.75±2.4^{ns}	4.86±2.2^{ns}	1.58±1.9^{ns}
Semitendinosus	6.74±2.0***	2.89±2.1^{-}*	6.06±2.4***	4.47±2.4^{ns}	1.35±2.0^{ns}
1.GG	4.67±2.2^{ns}	3.83±2.2^{ns}	4.40±2.3^{ns}	4.97±2.2^{ns}	1.58±2.5^{ns}
2.GG,GG+0.50	4.63±1.9^{-}*	3.31±1.9^{ns}	4.25±2.1^{ns}	4.34±2.0^{ns}	1.04±1.4^{ns}
3.GG+AL	6.28±2.1**	3.12±2.2^{-}*	5.73±2.5***	4.64±2.3^{ns}	1.45±2.0^{ns}
4.GG+0.50	5.44±2.3^{ns}	2.97±2.0^{ns}	4.85±2.6^{ns}	5.23±2.2^{ns}	1.04±1.5^{ns}
5.GG+0.50,AL	5.67±1.9^{ns}	4.26±1.8^{ns}	4.93±2.0^{ns}	4.65±1.4^{ns}	0.57±1.0^{ns}
6.GG+0.50,AL2	5.48±2.0^{-ns}	4.38±2.2^{ns}	4.85±2.4^{ns}	5.11±1.9^{ns}	1.13±1.8^{ns}
7.AD LIBITUM	5.63±2.3^{ns}	3.67±2.3^{ns}	4.88±2.5^{ns}	4.81±2.4^{ns}	1.58±1.9^{ns}

From the analysis of RDA mapped with SAT data (Tables 2 and 3) no significant differences were observed among the two breeds for meat quality. With regards to differences between muscles, the LD muscle was found to be positively (P≤0.05) correlated for appearance, flavour,

texture, acceptability, and juiciness and negatively (P≤0.05) correlated for firmness and toughness. Whereas the ST muscle was negatively (P≤0.05) correlated for flavour, texture, acceptability, and juiciness and positively (P≤0.05) correlated for firmness and toughness. No significant differences were observed for GM.

With regards to dietary effects; GG+GG+0.50 concentrate was negatively (P≤0.05) correlated for firmness. GG+AL concentrate was negatively (P≤0.05) correlated for appearance, flavour, texture, acceptability and juiciness and positively (P≤0.05) correlated for firmness and toughness. Both methods showed similarities in results but with additional information provided from the RDA mapped with SAT data.

IV. CONCLUSION

According to data from the 8-point hedonic scale, a breed difference existed for texture. The Limousin was significantly better for texture than the Charolais. For the various muscles and diets, some significant differences were observed. The LD muscle was scored the best of the three muscles as it was more tender, softer, with better flavour, better texture and better overall acceptability. The GM muscle also showed some positive significances having good texture, good overall acceptability and was tender however the ST muscle scored the poorest for quality, being tougher, poorer flavour, firmer, poorer texture and poorer overall acceptability. For diets, GG+AL concentrate scored as tougher than all other treatment groups. GG+0.50+AL concentrate 2 (fish oil) scored best for flavour. AL concentrate scored the best for overall texture and overall acceptability. From examining data from the continuous line scale, the LD muscle had a high significance for being closer to 'Not Juicy'.ST was highly significant for being tougher than LD. Furthermore, animals on the diet of GG + AL concentrates appear to produce meat which is not liked for appearance, flavour, texture or acceptability. These steaks were also found to be firmer, less juicy and tougher than animals on all other diets.

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