EFFECTS OF SILAGE PLANT SPECIES AND BREED ON CARCASS AND MEAT QUALITY OF FINISHING BULLS USING FORAGE-BASED BEEF PRODUCTION SYSTEMS

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Abstract – The objectives of the study were to determine the effects of silage plant species and breed on meat quality of finishing bulls. The experiment comprised 30 Angus (AA) and 30 Nordic Red (NR) bulls. Both breeds were randomly allotted to the three experimental diets. The compositions (g/kg dry matter) of the diets were: TS = timothy silage (650) and rolled barley (350), TAS = timothy silage (325), alsike clover silage (325) and rolled barley (350), AS = alsike clover silage (650) and rolled barley (350). The target for average slaughter age was 500 days. The loin (*longissimus dorsi*) samples were analysed for pH, colour, shear force, drip loss, sensory analysis and fatty acid profile. No diet effects on the meat quality were observed. The loin of the AA bulls had lower pH and shear force values and higher marbling score compared to the NR bulls. Muscle lightness, redness and yellowness values of the AA bulls were higher than those of the NR bulls. The AA bulls got higher scores in all sensory analyses compared to the NR bulls. The n-6/n-3 fatty acid ratio in the *longissimus dorsi* of the NR-bulls was 45% higher compared to the AA-bulls.

Key Words – clover, feeding, *longissimus dorsi*, *Phleum pratense*, timothy, *Trifolium hybridum*.

I. INTRODUCTION

In parts of northern Europe the limitations of climate restrict the area suitable for arable cropping, and grassland is particularly important in meeting the feed requirements of beef cattle. Most of the forage for growing cattle in Nordic countries is based on silage mixtures of different grasses [timothy (*Phleum pratense*), meadow fescue (*Festuca pratensis*), tall fescue (*Festuca arundinacea*)] and red clover (*Trifolium pratense*). Although timothy and meadow fescue are predominantly used in grassland farming in Finland, clovers may play an increasingly significant role in future silage production because of their nitrogen fixing ability. In northern Finland alsike clover (*Trifolium hybridum*) is an interesting alternative forage crop because it is well suited to acidic, organic soils contrary to most other clovers.

There are only a few reports comparing clover silages or mixed grass/clover silages to pure grass silages in the diet of finishing cattle. Lafrenière *et al*. (2012) reported that shear force values for grilled *longissimus* muscle steaks were lower in beef steers fed red clover-grass silage vs. steers fed grass silage. Nevertheless, silage did not have any effect on marbling, quality grade or pH value [1]. However, there is paucity of published information on the carcass and meat quality of finishing bulls when grass silage is partly or completely replaced by alsike clover silage. Therefore, our objectives were to determine the effects of silage plant species (alsike clover vs. grass) and cattle breed (Angus vs. Nordic Red) on carcass characteristics, meat quality and meat fatty acid profile of finishing bulls. The population structure of the Nordic Red dairy cattle is an admixture of Finnish Ayrshire, Danish Red and Swedish Red populations.

II. MATERIALS AND METHODS

A feeding experiment was conducted in the experimental barn of Natural Resources Institute Finland in Ruukki, Finland. The experiment comprised in total 30 Aberdeen Angus (AA) and 30 Nordic Red (NR) bulls. All animals, with an initial live weight (LW) of 479 (±37.1) kg (AA) and 366 (±68.9) kg (NR), were purchased from commercial herds. At the start of the experiment the animals were on average 335 (±17.6) (AA) and 303 (±35.4) (NR) days old. During the experiment the bulls were housed in an uninsulated barn in pens (10.0 × 5.0 m; 5 bulls in each pen), providing 10.0 m^2/bull.

The experimental silages were produced at the experimental farm of Natural Resources Institute Finland in Ruukki (64°44'N, 25°15'E) and harvested from either timothy (TS) or alsike clover (AS) stands. TS was harvested at heading stage of timothy (on August 9, regrowth) and AS at flowering of alsike clover (on July 5 and September 19, primary growth and regrowth, respectively). Both silages were slightly wilted and precision chopped. According to botanical analysis, TS contained timothy [960 g dry matter (DM)/kg DM] and other plants (40). Respectively, AS contained alsike clover (639) and other plants (361). Both silages were ensiled in bunker silos and treated with a formic acid-based additive (AIV ÄSSÄ; Taminco Finland Ltd) applied at a rate of 5 L/tonne of fresh forage.

The bulls were fed a total mixed ration *ad libitum*. Both AA and NR bulls were randomly allotted to the three experimental diets (TS, TAS, AS). The compositions (g/kg DM) of these diets were: TS = timothy silage (650) and rolled barley (350), TAS = timothy silage (325), alsike clover silage (325) and rolled barley (350), AS = alsike clover silage (650) and rolled barley (350). The bulls were weighed on two consecutive days at the beginning of the experiment and before slaughter. The bulls were selected for slaughter based on age, and slaughtered in five batches. The target for average slaughter age was 500 days, and the slaughter age was used as the end point of the study. After slaughter the carcasses were weighed hot. The cold carcass weight was estimated as 0.98 of the hot carcass weight. Dressing proportions were calculated from the ratio of cold carcass weight to final LW. The carcasses were classified for conformation and fatness using the EUROP quality classification [2].

After classification the carcasses were chilled overnight below 7 °C. One day after the slaughter the pH-value of the loin was measured with a Knick 651 instrument with Inlab Solid electrode (Mettler Toledo) at the level of the 1st lumbar vertebra in the middle part of the *longissimus dorsi*. Meat color of the loin was measured after a bloom time of half an hour with a Minolta Cr-200 handheld chroma-meter (Minolta Camera Co., Ltd., Osaka, Japan). The marbling score of the loin (at the 1st lumbar vertebra) was evaluated visually by using a six-point scale (0=devoid to 5=abundant).

During cutting the loin was cut at the level of the 1st lumbar vertebra, and the achieved 3 kg loin sample between the 1st and the 5th lumbar vertebra was taken and vacuum packed for further analysis. Total ageing time of the loin samples was 12 days at 4 °C. Thereafter samples were analysed for drip loss, Warner-Bratzler shear force and for tenderness, juiciness and beef flavour (sensory analysis) as described by Pesonen et al. (2013). The fatty acid composition in intramuscular fat of the loin was analyzed using gas chromatography [4].

The data were subjected to analysis of variance using the SAS MIXED procedure (version 9.3, SAS Institute Inc., Cary, NC). The statistical model used was $y_{ijkl} = \mu + \gamma_k + \alpha_i + \beta_j + (\alpha\times\beta)_{ij} + e_{ijkl}$, where μ is the intercept and e_{ijkl} is the random error term associated with l^{th} animal. α_i, β_j and $(\alpha\times\beta)_{ij}$ are the fixed effects of i^{th} silage (TS, TAS, AS) and j^{th} breed (AA, NR) and their interaction, respectively, while γ_k is the random effect of the slaughtering batch (l=1,...,5). Differences between the treatments were tested using orthogonal contrasts: (1) AA vs. NR, (2) linear effect of alsike clover silage inclusion, (3) quadratic effect of alsike clover inclusion, (4) linear interaction between breed and alsike clover inclusion, and (5) quadratic interaction between breed and alsike clover inclusion.

III. RESULTS AND DISCUSSION

The average slaughter age of the bulls was 505 days and there were no significant effects on breed or feeding treatment on it (Table 1). The carcass gain of the AA-bulls was 44% higher than that of the NR-bulls (844 vs. 587 g/d) (P<0.001). The carcass weight and carcass conformation score of the AA-bulls were also higher than the corresponding values of the NR-bulls (P<0.001).

Table 1 Effects of different feeding strategies on carcass and meat quality of finishing Angus and Nordic Red bulls. Feedings: TS = timothy silage + rolled barley, TAS = timothy-alsike clover -silage + rolled barley, AS = alsike clover silage + rolled barley. SEM = standard error of mean. Statistical significance (orthogonal contrasts): 1= Angus vs. Nordic Red, 2 = alsike clover, linear effect, 3 = alsike clover, quadratic effect, 1×2 = linear interaction between breed and alsike clover inclusion, 1×3= quadratic interaction between breed and alsike clover inclusion. EUROP conformation: 1 = poorest, 15 = excellent. EUROP fat score: 1 = leanest, 5 = fattest. Marbling score: 0 = devoid, 5 = abundant. Sensory analysis: scale from 1 to 7. Tenderness: 1 = very tough, 7 = very tender. Juiciness: 1 = very dry, 7 = very juicy, Beef flavour: 1 = very non beef like, 7 = very beef like. SFA = saturated fatty acids. MUFA = monounsaturated fatty acids. PUFA = polyunsaturated fatty acids.

Breed	Angus			Nordic Red			SEM	Statistical significance (P-values)				
Feeding	TS	TAS	AS	TS	TAS	AS		1	2	3	1×2	1×3
Initial live weight, kg	481	480	476	373	367	358	3.2	0.02	0.32	0.79	0.64	0.70
Final live weight, kg	708	704	703	609	600	611	12.1	<0.001	0.88	0.63	0.75	0.71
Slaughter age, d	495	486	505	504	520	519	8.4	0.54	0.30	0.78	0.19	0.45
Carcass weight, kg	379	379	373	302	302	306	5.9	<0.001	0.81	0.87	0.41	0.65
Carcass gain, g/d	866	886	780	589	573	599	36.3	<0.001	0.33	0.54	0.23	0.23
Dressing proportion, g/kg	535	538	530	496	503	501	2.9	<0.001	0.87	0.08	0.13	0.85
EUROP conformation	8.4	8.5	8.1	4.9	5.0	5.5	0.25	<0.001	0.51	0.87	0.14	0.32
EUROP fat score	3.1	3.0	2.9	2.3	1.9	2.0	0.12	<0.001	0.07	0.25	0.76	0.29
Meat quality												
pH (24 h *post mortem*)	5.57	5.53	5.54	5.66	5.75	5.68	0.045	<0.001	0.90	0.43	0.51	0.09
Marbling score (0-5)	1.56	1.63	1.66	1.06	1.06	1.50	0.262	0.08	0.21	0.65	0.27	0.36
Drip loss, %	0.22	0.19	0.29	0.27	0.32	0.32	0.042	0.42	0.18	0.46	0.81	0.29
WB shear force, N/4 cm^2	48.8	53.0	49.4	58.8	65.7	54.8	4.02	0.005	0.88	0.33	0.72	0.76
Colour												
L (lightness)	36.2	37.1	37.6	34.4	32.8	34.6	0.75	<0.001	0.35	0.20	0.46	0.02
a (redness)	22.6	22.6	23.4	21.1	21.0	20.7	0.74	<0.001	0.99	0.87	0.47	0.85
b (yellowness)	7.5	7.2	7.6	6.5	5.7	5.8	0.43	<0.001	0.57	0.22	0.53	0.47
Sensory analysis												
Tenderness	5.8	5.8	5.7	5.1	5.3	4.8	0.22	0.001	0.15	0.19	0.44	0.34
Juiciness	5.7	5.8	5.6	5.4	5.5	5.4	0.13	0.01	0.45	0.50	0.98	0.78
Beef flavour	5.9	5.9	5.9	5.6	5.7	5.7	0.13	0.006	0.71	0.46	0.69	0.70
Fatty acid profile of *longissimus dorsi* muscle (% of total fatty acids)												
SFA	45.92	44.33	44.11	42.44	43.29	44.52	1.062	0.01	0.98	0.48	0.05	0.95
MUFA	46.27	47.20	47.72	48.99	47.41	46.79	1.001	0.06	0.91	0.96	0.09	0.85
PUFA	6.71	7.52	7.38	7.53	8.18	7.89	0.677	0.27	0.55	0.39	0.50	0.79
*n*6/*n*3fatty acid ratio	3.01	2.89	2.90	4.32	4.30	4.11	0.181	<0.001	0.22	0.72	0.57	0.46

The carcass fat score of the AA-bulls was 43% higher than that of the NR-bulls (P<0.001). Corresponding differences in growth and carcass characteristics between beef and dairy breeds has been demonstrated earlier in numerous studies [5, 6]. There were no significant effects of the feeding treatments on the gain, carcass weight, dressing proportion or carcass conformation (Table 1). However, AS inclusion tended to decrease the carcass fat score (P=0.07). In some earlier studies it has been observed that also a mixture of grass and red clover tended to result in lower fat cover of steers [1] or bulls [7] compared with pure grass silage. There were no significant interactions for gain or carcass characteristics between breed and feeding treatment.

Breed had clear effects on meat quality (Table 1). The loin of the AA bulls had lower pH (P<0.001) and WB shear force (P=0.005) values and higher marbling score compared to the NR bulls. Further, muscle lightness (L), redness (a) and yellowness (b) values of the AA bulls were higher than those of the NR bulls (P<0.001). In muscle lightness also a significant quadratic interaction between breed and alsike clover inclusion was observed. The AA bulls got higher scores in all sensory analyses compared to the NR bulls (Table 1). The loin samples of the AA-bulls contained a higher proportion of saturated fatty acids (SFA) (P=0.01) and tended to contain lower proportion of monounsaturated fatty acids (MUFA) (P=0.06) compared to the NR bulls. In addition, there was a significant linear interaction between breed and alsike clover inclusion in the loin SFA proportion. The *n*-6/*n*-3 fatty acid ratio of the NR-bulls was 45 % higher than the corresponding value of the AA-bulls, on average (P<0.001). No significant effects of the feeding treatments on the meat quality or fatty acid profile of *Longissimus dorsi* muscle were observed (Table 1).

The slaughter age was used as the end point of this experiment, and therefore the limitation of the study is that the breed effects are partly confounded with carcass weight and carcass fat score. This, of course, affects the meat quality results. It is, for example, possible that the differences in carcass fat score between breeds affected to differences in fatty acid composition because according to literature [8], carcass fat score affects meat fatty acid profile. However, the targeted slaughter age is near the average ages for slaughtered bulls of these breeds in Finland. Therefore, the present results are valid from a practical point of view.

IV. CONCLUSION

In conclusion, breed differences between the AA and NR bulls in carcass traits and meat quality were observed when the bulls were slaughtered at the slaughter age of 500 days. The results indicate that AA bulls produced healthier meat with a lower *n*-6/*n*-3 fatty acid ratio compared to NR bulls. According to this study replacing timothy by alsike clover in the diet did not affect carcass or meat quality of the bulls.

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