Effects of supplementary concentrate level and separate or total mixed ration feeding on performance of growing dairy bulls

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A randomised complete block design was used to study the effects on animal performance of (1) the increasing level of supplementary concentrate with grass silage (GS), and (2) feeding GS and concentrates separately or as a total mixed ration (TMR). A feeding experiment comprised 32 dairy bulls with average initial live weight of 145 kg. The feeding treatments were: (1) GS (660 g kg^{-1} dry matter intake) plus medium level of rolled barley (330) offered separately, (2) GS (660) plus medium level of rolled barley (330) offered as TMR, (3) GS (330) plus high level of rolled barley (660) offered separately, and (4) GS (330) plus high level of rolled barley (660) offered as TMR. During the experiment (398 days) the bulls were fed *ad libitum* either GS or TMR. The increasing concentrate level increased energy intake, carcass gain and dressing proportion of the bulls but had no effects on carcass conformation or fat score. TMR feeding had no effects on carcass gain, dressing proportion, carcass conformation or fat score but increased dry matter and energy intake compared to the separate feeding.

Key words: beef production, concentrate supplementation, feeding method, growth, carcass characteristics, total mixed ration

Introduction

Beef production in Finland is mainly based on raising dairy bulls born in dairy farms. In the past, bulls fed on forage plus concentrates were generally offered their concentrate allowance once or twice daily separately from the forage. Recently, many beef producers have changed to using total mixed rations (TMR) to save labour and mechanise feeding. The rationale for TMR feeding is to achieve a relatively stable rumen pH and fermentation pattern throughout the day which would facilitate better cellulose digestion and a higher lipogenic to non-lipogenic volatile fatty acid ratio (Kaufmann 1976). Gordon et al. (1995) summarised 13 studies in which TMR feeding was compared with separate or twice daily feeding of concentrates in dairy cows. Feed intake increased 6% and milk yield 4% due to TMR feeding (Gordon et al. 1995). Caplis et al. (2005) concluded that TMR feeding had no effect on growth performance or carcass traits compared with separate feeding in finishing crossbred steers even though TMR feeding increased silage and total dry matter (DM) intake (DMI). Keane et al. (2006) reported that feeding a TMR increased intake at the low (375 g kg^{-1} DM) but not at a high (750 g kg^{-1} DM) concentrate level compared to separate feeding in beef steers but feeding method had no effects on overall live weight gain (LWG) or slaughter traits.

In intensive beef production, grass silage (GS) is typically supplemented with grain to increase the energy and nutrient intake of growing bulls. The effects of concentrate level on the performance of growing cattle have been extensively studied. It is well established that good quality silage can support high levels of performance with moderate concentrate supplementation (e.g. Randby et al. 2010, Pesonen et al. 2014b). However, increasing the allowance of concentrate has often improved the growth rate and decreased the days until slaughter (Huuskonen et al. 2007, Manni et al. 2013, Pesonen et al. 2013). Nevertheless, it is widely recognized that high concentrate levels can lead to risks of diseases (e.g. rumen acidosis) due to a high starch load (Krause and Oetzel 2006). Further, rumen acidosis is known to be related to diseases such as ruminitis, rumen paraketosis, liver abscesses, laminitis and bloat (Nocek 1997, Galyean and Rivera 2003, Krause and Oetzel 2006). Due to a more stable rumen pH throughout the day it can be expected that compared to separate feeding TMR could reduce the risk of rumen acidosis and thereby improve the performance of the growing cattle fed high concentrate proportions. However, there exists only a few published comparisons of TMR and separate feeding in growing and finishing cattle fed GS based diets and different concentrate levels. Therefore, the objectives of this study with growing dairy bulls were (1) to determine the effects of feeding method (silage and concentrates offered separately or as TMR), (2) to determine the current response to increasing level of concentrate with GS, and (3) to determine if there were interactions between supplementary concentrate level and feeding method on intake, growth performance and carcass characteristics.

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Materials and methods

Animals and housing

A feeding experiment was conducted in the experimental barn of MTT Agrifood Research Finland in Ruukki. Animals were managed according to the Finnish legislation regarding the use of animals in scientific experimentation. The feeding experiment comprised in total 32 Nordic Red bulls. All animals were purchased from local dairy farms.

The bulls were placed in an insulated barn in adjacent tie-stalls. The width of the stalls was 70–90 cm for the first six months and 113 cm until the end of the experiment. The bulls were tied with a collar around the neck, and a 50 cm long chain was attached to a horizontal bar 40–55 cm above the floor. The floor surface was solid concrete under the forelegs and metal grids under the hind legs. No bedding was used on the floor.

Feeding and experimental design

At the beginning of the feeding experiment the animals with average live weight (LW) of 145 kg (±18.6) and 122 days (±4.8) of age were divided into eight blocks of four animals by LW. Within block the animals were randomly allotted to one of four treatments (8 bulls per treatment).

The composition (g kg^{-1} DM of the total diet) of the four feeding treatments were:

- S330: GS (660) plus medium level of rolled barley (330) offered separately.
- TMR330: GS (660) plus medium level of rolled barley (330) offered as TMR.
- S660: GS (330) plus high level of rolled barley (660) offered separately.
- TMR660: GS (330) plus high level of rolled barley (660) offered as TMR.

During the feeding experiment, which lasted for 398 days, the bulls were fed *ad libitum* (proportionate refusals of 5%) either GS or TMR. On S330 and S660 diets the quantity of rolled barley offered to the bulls was estimated on the basis of the previous day's silage intake. The animals were fed three times per day (at 0800, 1200 and 1800 hours), and intakes were measured separately for each individual bull. Refused feed was collected and measured at 0700 daily. The bulls had free access to water from an open water bowl during the experiment. The daily ration for the bulls included also 150 g of a mineral mixture (Seleeni Hertta Muro; Hankkija Ltd, Hyvinkää, Finland: Ca 205, P 15, Na 80, Mg 70 g kg^{-1}). A vitamin mixture (Xylitol ADE-Vita; Hankkija Ltd, Hyvinkää, Finland: A 2,000,000 IU kg^{-1}, D_3 400,000 IU kg^{-1}, E DL-α-tocopheryl acetate 1,000 mg kg^{-1}, E DL-α-tocopheryl 900 mg kg^{-1}, Se 10 mg kg^{-1}) was given at 50 g per animal weekly. One bull (S660) was excluded from the study due to hoof problems. Otherwise all bulls were healthy and completed the entire study.

The GS used in the feeding experiment was produced at the experimental farm of MTT Agrifood Research Finland in Ruukki, Finland (64°44'N, 25°15'E). The GS was made from the primary growth, comprised of mixed timothy (*Phleum pratense*) and meadow fescue (*Festuca pratensis*) stands and was harvested at early heading stage of timothy using a mower conditioner, wilted for 5 h and harvested using a precision-chop forage harvester. The GS was ensiled in bunker silos and treated with a formic acid-based additive (AIV-2 Plus; Kemira Ltd., Oulu, Finland: 760 g formic acid kg^{-1}, 55 g ammonium formate kg^{-1}) applied at a rate of 5 litres t^{-1} of fresh forage.

Feed and faecal sampling and analysis

Silage sub-samples for chemical analyses were taken twice a week, pooled over periods of four weeks and stored at –20 °C. Thawed samples were analysed for DM, ash, crude protein (CP), ether extract, neutral detergent fibre (NDF), starch, silage fermentation quality (pH, lactic and formic acids, volatile fatty acids, soluble and ammonia N content of total N) and digestible organic matter (DOM) in DM (D-value). Barley sub-samples were collected weekly, pooled over periods of 12 weeks and analysed for DM, ash, CP, ether extract, NDF and starch.

Fresh silage samples were analysed for fermentation quality by electrometric titration as described by Moisio and Heikonen (1989). The DM concentration was determined by drying at 105 °C for 20 h and organic matter (OM) concentration by ashing at 600 °C for 2 h. Oven DM concentration of silages was corrected for the loss of volatiles according to Huida et al. (1986). After drying the samples were milled using sample mill (Sakomylly KT-3100, Koneteollisuus Oy, Helsinki, Finland) and 1 mm sieve. The CP content of feeds was determined using a Dumas-type N analyser (Leco FP-428; Leco Corporation, St Joseph, MI, USA). Concentration of NDF was determined according to Van Soest et al. (1991) using Na-sulphite, without amylase for forages and presented ash-free. Starch was determined as described by Huuskonen and Joki-Tokola (2010) and ether extract as reported by Huuskonen (2013). The silage samples were analysed for D-value as described by Huhtanen et al. (2006). The D-value results were calculated with correction equations to convert pepsin-cellulase solubility values into *in vivo* digestibility by equations based on a dataset comprising of Finnish *in vivo* digestibility trials.

The metabolisable energy (ME) concentration of the GS was calculated as 0.016 x D-value (MAFF 1984). The ME concentrations of the concentrate feeds were calculated based on concentrations of digestible crude fibre, CP, crude fat and nitrogen-free extract described by MAFF (1984). The digestibility coefficients of rolled barley were taken from the Finnish Feed Tables (MTT 2014). The values of amino acids absorbed from the small intestine (AAT) and the protein balance in the rumen (PBV) were calculated according to the Finnish feed protein evaluation system (Tuori et al. 1998, MTT 2014).

Apparent diet digestibility was determined for all animals when the bulls were 327 ± 25.9 kg LW, on average. Feed and faecal samples were collected twice a day (at 0700 and 1500 hours) during the 5-day collection period and stored frozen prior to analyses. The samples were analyzed for DM, ash and NDF as described above. The diet digestibility was determined using acid-insoluble ash (AIA) as an internal marker (Van Keulen and Young 1977).

Weightings, slaughter procedures and carcass quality measurements

The bulls were weighed on two consecutive days at the beginning of the experiment and thereafter single weightings were done approximately every 28 days. Before slaughter the animals were weighed on two consecutive days. The target for average slaughter age of the bulls was 520 days, and slaughter age was used as the end point of the study. Overall, the feeding experiment lasted 398 days.

The LWG was calculated as the difference between the means of the initial and final LW divided by the number of growing days. The estimated rate of carcass gain was calculated as the difference between the final carcass weight and the carcass weight in the beginning of the experiment divided by the number of growing days. The carcass weight at the start of the experiment was assumed to be 0.50 × initial LW based on earlier studies (unpublished data).

The bulls were slaughtered in the Atria Ltd. commercial slaughterhouse in Kuopio, Finland. 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 (EC 2006). For conformation, the development of the carcass profiles, in particular the essential parts (round, back, shoulder), was taken into consideration according to the EUROP classification (E: excellent, U: very good, R: good, O: fair, P: poor) and for fat cover degree, the amount of fat on the outside of the carcass and in the thoracic cavity was taken into account using a classification range from 1 to 5 (1: low, 2: slight, 3: average, 4: high, 5: very high). Each level of the conformation scale was subdivided into three sub-classes to produce a transformed scale ranging from 1 to 15, with 15 being the best conformation.

Statistical methods

The results are shown as least squares means. The normality of analysed variables was checked using graphical methods: box-plot and scatter plot of residuals and fitted values. The data were subjected to analysis of variance using the SAS MIXED procedure (version 9.3, SAS Institute Inc., Cary, NC). The following statistical model was used to analyse all studied parameters:

$$y_{ijkl} = \mu + \gamma_k + \alpha_i + \beta_j + \alpha\times\beta_{ij} + e_{ijkl},$$

where μ is intercept, γ_k is the random effect of k[th] block (k=1,…,8) and e_{ijkl} is the random error term associated with l[th] animal. α_i (i=1,2), β_j (j=1,2) and $\alpha\times\beta_{ij}$ are the fixed effects of i[th] feeding method (TMR, separate), j[th] concentrate level (330, 660 g kg^{-1} DM) and their interaction, respectively. *P*-values less than 0.05 are reported as statistically significant.

Results

The chemical compositions and nutritional values of the experimental feeds and total mixed rations used in the present experiment are given in Table 1.The GS used was of good nutritional quality as indicated by the D-value as well as the AAT and CP contents. The fermentation quality of the GS was also good as indicated by the low pH value and the low concentration of ammonia N and volatile fatty acids (Table 1). Barley grain used in the experiment had typical chemical composition and feed values. Because of the higher energy content of barley grain compared to the GS, increasing the concentrate proportion increased the calculated energy value of the ration (Table 1). Increasing the proportion of the concentrate also increased the DM and starch content, but decreased the NDF content of the ration.

Table 1. Chemical composition and feeding values of the grass silage, barley grain and total mixed rations (TMR) used in the feeding experiment.

	Grass silage	Barley grain	TMR330	TMR660
Dry matter (DM), g kg^{-1} feed	242	917	321	476
Organic matter (OM), g kg^{-1} DM	919	975	937	955
Crude protein, g kg^{-1} DM	135	120	130	125
Neutral detergent fibre (NDF), g kg^{-1} DM	538	205	427	316
Forage NDF in ration, g kg^{-1} DM	-	-	358	179
Ether extract, g kg^{-1} DM	46	22	38	30
Starch, g kg^{-1} DM	9	565	248	406
Metabolisable energy, MJ kg^{-1} DM	10.7	12.9	11.4	12.2
AAT, g kg^{-1} DM	79	97	85	91
PBV, g kg^{-1} DM	16	-25	2	-11
Digestible OM in DM, g kg^{-1} DM	669	ND		
Fermentation quality of the grass silage				
pH	3.72			
Volatile fatty acids, g kg^{-1} DM	18			
Lactic + formic acid, g kg^{-1} DM	47			
In total N, g kg^{-1}				
NH_4N	39			
Soluble N	420			

Number of samples: grass silage 14, barley grain 5.
TMR330 = concentrate level 330 g kg^{-1} DM.
TMR660 = concentrate level 660 g kg^{-1} DM.
AAT = Amino acids absorbed from small intestine.
PBV = Protein balance in the rumen. ND = Not determined.

There were no significant interactions for intake parameters between the feeding method and the concentrate level (Table 2). TMR feeding increased total DMI, ME intake (MEI) and CP intake of the bulls by 10, 9 and 10%, respectively, compared to separate feeding (p<0.001). In addition, TMR feeding increased NDF (p<0.01) and starch (p<0.001) supply by 9 and 11%, respectively. Concentrate level had no significant effects on DM or CP intake but the increasing concentrate allowance increased ME and starch intake (by 11 and 100%, respectively) and decreased NDF intake of the bulls by 23% compared to separate feeding (p<0.001). There were no significant interactions for digestibility coefficients between the feeding method and the concentrate level (Table 2). The feeding method had no effect on diet apparent DM digestibility (DMD) or organic matter digestibility (OMD) but separate feeding tended (p=0.08) to improve NDF digestibility (NDFD) compared to TMR feeding. Increasing concentrate level led to significantly decreased DMD, OMD and NDFD (Table 2).

Table 2. Daily dry matter (DM) and nutrient intake and apparent diet digestibility of the growing bulls fed either separate or total mixed ration (TMR) feeding with two different concentrate levels.

Feeding method (F)	TMR		Separate			*p*-value		
Concentrate level (C), g kg^{-1} DM	330	660	330	660	SEM	F	C	F×C
Number of animals	8	8	8	7	-	-	-	-
Intake								
Grass silage, kg DM d^{-1}	5.19	2.65	4.62	2.42	-	-	-	-
Concentrate, kg DM d^{-1}	2.59	5.30	2.31	4.91	-	-	-	-
Total DM, kg d^{-1}	7.78	7.95	6.93	7.33	0.178	<0.001	0.11	0.48
Metabolisable energy, MJ d^{-1}	89.0	97.3	80.2	90.5	2.12	<0.001	<0.001	0.62
Crude protein, g d^{-1}	1000	988	896	912	22.8	<0.001	0.94	0.52
Neutral detergent fibre, g d^{-1}	3289	2486	2940	2329	66.9	0.002	<0.001	0.14
Starch, g d^{-1}	1499	2984	1379	2761	53.4	<0.001	<0.001	0.32
Digestibility coefficients								
DM	0.769	0.730	0.757	0.739	0.0082	0.92	0.003	0.22
Organic matter	0.788	0.746	0.777	0.758	0.0083	0.89	0.002	0.19
Neutral detergent fibre	0.697	0.611	0.705	0.634	0.0135	0.08	<0.001	0.12

SEM = Standard error of mean.

There were no significant interactions for final LW or LWG between the feeding method and the concentrate level (Table 3). The feeding method had no effect on LWG but increasing concentrate level led to a 6% improvement of daily LWG ($p<0.05$). Carcass gain was not affected by feeding method but increasing concentrate allowance improved it 13%, on average ($p<0.01$). There was also a significant interaction ($p<0.05$) between feeding method and concentrate level for carcass gain. Carcass gain improved more with separate feeding than with TMR feeding as a consequence of increased concentrate level (Table 3).

Table 3. Growth performance, feed conversion and carcass characteristics of the growing bulls fed either separate or total mixed ration (TMR) feeding with two different concentrate levels.

Feeding method (F)	TMR		Separate			*p*-value		
Concentrate level (C), g kg^{-1} DM	330	660	330	660	SEM	F	C	F×C
Initial live weight, kg	145	146	145	145	2.6	0.86	0.82	0.98
Final live weight, kg	576	590	557	597	13.8	0.56	0.052	0.33
Carcass weight, kg	303	315	280	324	8.1	0.22	0.002	0.048
Live weight gain (LWG), g d^{-1}	1083	1117	1036	1136	33.1	0.56	0.045	0.30
Carcass gain, g d^{-1}	580	609	522	631	19.6	0.22	0.002	0.042
Feed conversion								
Kg dry matter/kg LWG	7.19	7.14	6.73	6.47	0.138	<0.001	0.27	0.43
Kg dry matter/kg carcass gain	13.44	13.09	13.46	11.64	0.494	0.19	0.034	0.13
MJ ME/kg LWG	82.3	87.5	77.9	79.9	1.63	0.048	0.026	0.31
MJ ME/kg carcass gain	153.8	160.3	155.9	143.7	5.85	0.24	0.66	0.10
g crude protein/kg LWG	924	888	870	805	17.9	<0.001	0.008	0.40
g crude protein/kg carcass gain	1727	1628	1741	1447	65.1	0.26	0.005	0.13
Carcass characteristics								
Dressing proportion, g kg^{-1}	527	534	505	542	10.6	0.39	0.042	0.16
Conformation score, EUROP	4.88	5.00	4.38	4.99	0.257	0.25	0.15	0.32
Fat score, EUROP	2.50	2.63	2.38	2.26	0.180	0.17	0.94	0.49

SEM = Standard error of mean.
DM = Dry matter.
ME = Metabolisable energy.
Conformation: (1 = poorest, 15 = excellent).
Fat score: (1 = leanest, 5 = fattest).

There were no significant interactions for feed or energy conversion between the feeding method and the concentrate level (Table 3). However, due to differences in intake and growth parameters, there were differences between the treatments. Both feed (kg DM/kg LWG) and energy (MJ ME/kg LWG) conversion rates improved in separate feeding compared to TMR feeding. However, there were no significant differences between feeding methods when calculated per carcass gain (Table 3). Furthermore, feed conversion (kg DM/kg carcass gain) improved and energy conversion (MJ ME/kg LWG) decreased with increasing concentrate proportion (p<0.05).

The carcass weight of the bulls was 305 kg, on average. The feeding method had no effect on carcass weight but increasing concentrate allowance increased it by 9% (p<0.01). There was also a significant interaction (p<0.05) between feeding method and concentrate level for carcass weight. Carcass weight increased more with separate feeding than with TMR feeding when concentrate level was increased (Table 3). There were no interactions for dressing proportion, carcass conformation score or carcass fat score between the feeding method and the concentrate level. Feeding method had no effect on dressing proportion, conformation score or fat score. Concentrate level had no significant effects on conformation or fat score but increasing concentrate allowance increased dressing proportion by 4% (p<0.05).

Discussion

Feeding method

As in the present study, a positive effect of TMR feeding on DMI was noted previously in finishing steers (Caplis et al. 2005, Keane et al. 2006), finishing heifers (Cooke et al. 2004), fattening calves (Atwood et al. 2001) and in a meta-analysis based on a dataset of feeding experiments in growing cattle (Huuskonen et al. 2013). Earlier, Petchey and Broadbent (1980) compared separate or mixed feeding of silage and concentrates for finishing Friesian steers at silage:concentrate rations ranging from 0 to 1.0. Consistent with the present experiment, they reported that mixing increased DMI 9% compared to separate feeding with no evidence of an interaction between feeding method and concentrate level (Petchey and Broadbent 1980). It is suggested that some intake increases due to TMR feeding can be explained by the rejection of unpalatable feeds in unmixed rations, something that is difficult in TMR feeding (Phipps et al. 1984). In another case, DMI increases could be due to the extra processing that occurs during the mixing of the TMR or to the fact that the whole diet is constantly available (Caplis et al. 2005).

There seems to be no scientific published information available on the effects of separate vs. TMR feeding on diet digestibility of growing and finishing cattle. However, consistent with the present experiment, previous studies in dairy cows have not shown any significant effect of the method of feeding on DMD or OMD (Holter et al. 1977, Yan et al. 1998). In the present study the difference in NDFD was also small, although tended to be higher in the separate feeding compared to the TMR feeding. Whether this difference obtained in the present study was real or not is unclear, but this could reflect differences in DMI between feeding methods. Actually, difference in DMI was slightly greater during the 5-day collection period (12%) than average during the experiment (10%).

Consistent with the findings of Petchey and Broadbent (1980), Caplis et al. (2005) and Keane et al. (2006) there was no effect of mixing on LWG. On the contrary, Cooke et al. (2004) reported that mixing of maize silage, GS, straw and concentrates resulted in a LWG response of 15% for an intake increase of 4%. A possible explanation for the difference between the other findings and those of Cooke et al. (2004) may be that the forage used by Cooke et al. (2004) included maize silage, straw and GS whereas in other studies only grass silage was used. In dairy cows Yan et al. (1998) have stated that when a benefit was obtained to TMR feeding, forages other than GS were offered. As in the present experiment Cooke et al. (2004), Caplis et al (2005) and Keane et al. (2006) observed that feeding method (separate vs. TMR) had no effects on dressing proportion, carcass conformation or carcass fat score of growing and finishing cattle.

Concentrate level

It is well established that increasing concentrate allowance decreases silage intake and subsequently increases MEI (Randby et al. 2010, Manni et al. 2013, Pesonen et al. 2013) as in the present study. In the present experiment the concentrate proportion had no significant effects on the total DMI which is in line with results by Huuskonen et al. (2007) and Pesonen et al. (2014b) with bulls fed GS based rations. However, in many feeding experiments increasing concentrate level has also increased total DMI to some extent (Randby et al. 2010, Manni et al. 2013, Pesonen et al. 2013). The substitution rate (SR, decrease in silage DMI per kg increase of concentrate DMI) in the current experiment was 0.94 and 0.84 for TMR and separate feedings, respectively. This is in line with SR's observed at GS-based feedings reported by Keane (2010) with crossbred steers (0.82), Randby et al. (2010) with dairy bulls (0.75) and Manni et al. (2013) with dairy bulls (0.81). McNamee et al. (2001) concluded that concentrate level and silage feed value are major factors affecting the concentrate substitution rate. Caplis et al. (2005) found substitution rates for high digestibility silage of 0.29, 0.65 and 1.10 kg silage DM per kg concentrate DM for successive increments of concentrate equating to 0.31, 0.55 and 0.85 of total DMI, respectively.

The reduced DMD and OMD with higher concentrate allowance may be related to the rumen retention time of concentrate particles (Mulligan et al. 2001) and the negative effects of concentrate inclusion on forage digestibility (Hoover 1986). The reduction in NDFD due to increased concentrate level has been reported previously, for example, by Huuskonen et al. (2007) and Pesonen et al. (2013), and partly caused by dilution of forage fibre with more slowly digested concentrate fibre (Hoover 1986). In addition, the negative associative effect is attributed to a depression in fibre digestibility in the rumen and in the total digestive tract from inclusion of rapidly fermentable carbohydrates such as barley-based (starch) concentrate (Huhtanen and Jaakkola 1993) and sucrose (Khalili and Huhtanen 1991) in GS-based diets. According to Hoover (1986), added starch reduced fibre digestion through a series of events involving carbohydrate preference, reduced rumen pH and decreased cellulolytic organisms. A moderately reduced pH, to about 6.2, exacerbated the depression in the fibre digestion brought about by added starch; a more severe pH decrease, to 6.0, reduced cellulolytic microbes and severely limited fibre digestion. The initial reduction in fibre digestion, which was not pH-related, was referred to as “carbohydrate effect”, and suggests that an alternate, readily digested carbohydrate, can inhibit cellulose digestion (Hoover 1986).

Good quality silage can support high levels of growth with moderate concentrate supplementation but, however, increasing concentrate allowance has improved growth in several feeding experiments (Huuskonen et al. 2007, Randby et al. 2010, Manni et al. 2013, Pesonen et al. 2014a). In the present study observed increase in LWG was 13 and 39 g d^{-1} per 1kg increase in concentrate DMI for TMR and separate feedings, respectively, showing that responses to concentrate feeding can be rather limited with good quality silage. This is roughly consistent with Huuskonen et al. (2007) who reported an increase of 27 g d^{-1} in LWG per 1 kg increase in concentrate DMI. Nevertheless, in many cases growth responses have been greater such as observed by Martinsson (1990) (84 g d^{-1}), Aronen et al. (1992) (69 g d^{-1}) and Manni et al. (2013) (73 g d^{-1}). In contrast to expectations growth improved more with separate feeding than with TMR-feeding as a consequence of increased concentrate level. The explanation for this is not clear. However, these results indicate that the diet starch level of 400 g kg^{-1} DM is not too high for growing and finishing bulls when the diet includes forage NDF at least 180 g kg^{-1} DM. This is in line with Huuskonen et al. (2007) who observed that dairy bulls were healthy and grew well throughout the 338 days feeding experiment with concentrate level of 700 g kg^{-1} DM (starch 422 g kg^{-1} DM, forage NDF 163 g kg^{-1} DM).

The increasing effect of concentrate level on dressing proportion agrees with previous reports (Caplis et al. 2005, Keane et al. 2006, Pesonen et al. 2013). This is obvious because forages, generally, promote a large gut fill compared to concentrates (ARC 1980, Owens et al. 1995). In the present experiment, increasing concentrate proportion did not improved the carcass conformation, consistent with Huuskonen et al. (2007), Randby et al. (2010) and Manni et al. (2013) but contrary to Keane and Fallon (2001), Caplis et al. (2005) and Keane et al. (2006). Conversely to many earlier observations (Martinsson 1990, Keane and Fallon 2001, Caplis et al. 2005, Keane et al. 2006, Huuskonen et al. 2007), increasing concentrate proportion and MEI did not increase carcass fat score in the present study.

Overall, the present data showed that feeding a TMR increased feed intake of the bulls but had no effect on growth or carcass traits. This study showed that diets comprising high quality silage plus medium concentrate level can support high levels of growth. Nevertheless, including concentrate into the diet increased growth performance, carcass weight and dressing proportion of the bulls but had no effects on carcass conformation score or carcass fat score. This study also indicate that the diet starch level of 400 g kg^{-1} DM is not too high for growing and finishing bulls when the diet includes forage NDF at least 180 g kg^{-1} DM.

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