Livestock Science 191 (2016) 72–79

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

Effects of barley intake and allocation regime on performance of growing dairy bulls offered highly digestible grass silage

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ARTICLE INFO

Article history:
Received 30 November 2015
Received in revised form
30 June 2016
Accepted 4 July 2016

Keywords:
Barley grain
Beef production
Carcass quality
Feed conversion
Growth
Grass silage

ABSTRACT

The objective of this experiment was to examine effects of barley intake and allocation regime on performance of growing dairy bulls offered highly digestible grass silage, with digestible organic matter of 703 g/kg dry matter (DM). The feeding experiment comprised of a total of 33 bulls (17 Holstein and 16 Nordic Red) with an initial mean live weight of 230 kg and age of 200 days and a slaughter age of 566 days. During the feeding experiment the bulls were fed *ad libitum* either grass silage alone (GS) or a total mixed ration where rolled barley grain was added. Barley concentrations were either 300 g/kg DM during the whole experiment (SC) or 600 g/kg DM during only the early (DC) or late (IC) half of the growing period. When barley proportion was doubled in the diet during the early part of the growing period, it had no effect on the total DMI (SC vs. DC). Including barley in the diet during the late part of growing period increased barley intake by 30% ($P < 0.05$) compared to the other treatments where barley was given. Silage DM intake decreased on average by 27% ($P < 0.05$) when barley was included in the diet over the whole growing period (GS vs. others). Including barley in the diet during the late part of growing period increased LWG over the total growing period by 17% ($P < 0.05$) compared to the silage only treatment (IC vs. GS). When barley was included in the diet during the early part of the growing period, carcass fat score decreased by 20% ($P < 0.05$) compared to the treatment where barley was included in the diet during the late part of the growing period (DC vs. IC). Although good quality grass silage as a sole feed could support moderate to high levels of performance of growing cattle, including barley to the diet further improved the performance of animals. The present study demonstrated the ability of growing bulls to adapt to different feeding regimes without major effects on performance. This gives flexibility into choosing feeding strategies based on feed availability and prices resulting in potential benefits in the economy of beef production.

1. Introduction

Beef production in some systems, like in Finland, is mostly based on dairy breeds (Niemi and Ahlstedt, 2014). The decrease in dairy cattle population during recent years threatens to reduce the level of beef production. Already now there is a lack of domestic beef in Finland in relation to consumption. To compensate for the reduction in numbers of slaughtered animals, slaughterhouse pricing systems favour heavy carcasses. Consequently, average carcass weight has increased significantly, which has helped offset the reduction in beef production volumes. However, the challenge is to inhibit increasing carcass fatness of the heavy carcasses. Increased fatness is related to the physiological maturity state (Trenkle and Marple, 1983) and increased carcass weight (Keane and Allen, 1998; Keane and Fallon, 2001).

Market demand in Finland concerning carcass fat is different from those beef markets where marbled beef is favoured. In Finland, consumers generally favour low-fat products and the beef industry has stated that optimally two thirds of the carcasses would have a EUROP fat score of 2 and one-third a EUROP fat score of 3 (Herva et al., 2011). High-fat carcasses cause additional expenditures for the meat industry so that lean carcasses are favoured in the pricing and there are penalties for fat carcasses. For these reasons, carcass fat score is an important production parameter affecting the profitability of farms and the entire beef chain. However, this results in a conflict between a need of heavy carcasses and low carcass fatness.

Grass silage is a major feed component in many beef production systems like in Scandinavia, Ireland, UK, Australia and North

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http://dx.doi.org/10.1016/j.livsci.2016.07.004
1871-1413/

America, and especially during the winter feeding period (Keady et al., 2013). Good quality grass silage alone, containing digestible organic matter at least 700 g/kg DM and well fermented with low concentrations of fermentation acids, can support high levels of performance of growing cattle (Randby et al., 2010). In beef production, the nutritive value of grass silage is usually insufficient to meet target growth rates and diets are typically supplemented with concentrate feeds to improve performance of growing cattle.

Increasing the concentrate allowance typically decreases forage intake while total dry matter (DM), energy and nutrient intakes increase, which results in faster growth rate (Scollan et al., 2003; Randby et al., 2010; Manni et al., 2013). However, increase in growth per kg increase in concentrate DMI varies and in some cases responses to concentrate feeding can be rather limited (Martinsson, 1990; Manni et al., 2013; Huuskonen et al., 2014; Pesonen et al., 2014). Increased concentrate intake has improved carcass conformation (Keane and Fallon, 2001; Caplis et al., 2005), but it also has increased carcass fatness (Huuskonen et al., 2007; Keane and Drennan, 2009). One strategy to decrease carcass fatness could be to decrease DMI of animals towards the end of the growing period (Murphy and Loerch, 1994; Sainz et al., 1995). Another option would be to feed silage *ad libitum* but decrease concentrate intake during the late part of growing period, which has been studied only to a limited extent (Manni et al., 2013).

If the growth is divided into periods by restricting feed intake during a certain part of the growing period, the manipulated growth rate of animals depends on energy and nutrient intake (Cummins et al., 2007). Growth rate typically increases when feed or nutrient intake increases after a restriction period, even so much that it enables animals to catch up to the weight of animals whose growth was not reduced. This phenomenon is called compensatory growth (Nicol and Kitessa, 1995; Hornick et al., 2000). If there is a temporary shortage of the amount of feed, feed quality declines or feed prices fluctuate, manipulated growth by altering the amount and/or quality of feeds offered and energy intake of animals may be used successfully, provided that the animals have possibility to catch up the growth after restriction (Manni et al., 2013).

The objectives of this experiment were to determine the performance of growing dairy bulls when highly digestible grass silage was used as a sole feed and to determine the effects of concentrate allowance and allocation regime on the performance of the bulls. It was hypothesized that highly digestible grass silage alone can support moderate performance but that barley supplementation will improve the growth rate and carcass characteristics. It was also hypothesized that steady barley intake compared to periodic barley allocation (increased or decreased) prior to slaughter will change the growth pattern of the bulls but not affect the average growth rate during the whole experimental period. Furthermore, it was hypothesized that increasing or decreasing barley allowance prior to slaughter will increase or decrease carcass fat score, respectively, compared to a steady barley allowance.

2. Materials and methods

2.1. Animals and housing

A feeding experiment was conducted in the experimental barn of Natural Resources Institute Finland (Luke) in Ruukki, Finland starting on 15th January 2013 and ending on 16th January 2014. Animals were managed according to the Finnish legislation regarding the use of animals in scientific experimentation. In the beginning the feeding experiment comprised a total of 36 dairy bulls (20 Holstein and 16 Nordic Red). During the experiment two bulls were excluded from the study due to hoof problems (one GS and one SC bull) and one bull (SC) due to pneumonia. There was no reason to suppose that the diets had caused these problems. All animals were purchased from local dairy farms. In the pre-experimental period the calves were housed in an insulated barn in pens and fed hay, grass silage and concentrates (rolled barley and rapeseed meal). During the feeding experiment the animals were housed in tie-stalls. At the beginning of the experiment the bulls with average live weight (LW) of 230 (s.d. $\pm$36.9) kg and 200 ($\pm$24.9) days of age were divided into nine blocks of four animals each by LW and breed so that there were five Holstein blocks and four Nordic Red blocks. Within the block, the bulls were randomly allotted to one of the four feeding treatments (9 bulls per treatment).

2.2. Feeding management and experimental design

During the feeding experiment the bulls were fed *ad libitum* (proportionate refusals of 5%) either grass silage alone or a total mixed ration (TMR) composed of grass silage and rolled barley grain. Total mixed rations were carried out by a mixer wagon (Junkkari, Ylihärmä, Finland) once a day. The animals were fed three times per day (at 0800, 1200 and 1800 h). Refused feed was collected and measured at 0700 daily.

The compositions of the four dietary treatments were:

1. GS: Grass silage alone during the whole experimental period (12 months, from 200 to 566 days of age).
2. SC: Steady barley allowance. The TMR contained grass silage (700 g/kg DM) and barley (300 g/kg DM) during the whole experimental period.
3. IC: Increasing barley allowance. The bulls received grass silage alone during the early part of the experiment (six months, from 200 to 383 days of age) and then TMR containing grass silage (400 g/kg DM) and barley (600 g/kg DM) during the late part of the experiment (six months, from 383 to 566 days of age).
4. DC: Decreasing barley allowance. The bulls received TMR containing grass silage (400 g/kg DM) and barley (600 g/kg DM) during the early part of the experiment (six months, from 200 to 383 days of age) and grass silage alone during the late part of the experiment (six months, from 383 to 566 days of age).

The daily ration for all 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). A vitamin mixture (Xylitol ADE-Vita; Hankkija Ltd, Hyvinkää, Finland: A 2,000,000 IU/kg, D_3 400,000 IU/kg, E DL-α-tocopheryl acetate 1000 mg/kg, E DL-α-tocopheryl 900 mg/kg, Se 10 mg/kg) was given at 50 g per animal weekly. The bulls had free access to water from an open water bowl during the experiment.

The grass silages used in the present experiment were produced at the experimental farm of Natural Resources Institute Finland (Luke) in Ruukki, Finland (64°44′N, 25°15′E) in 2012 and 2013. The silages were made of the primary growth of timothy (*Phleum pratense*) stands and were harvested at early heading stage of timothy using a mower conditioner, wilted for 5 h and harvested using a precision-chop forage harvester. Harvest dates were 18 June 2012 and 13 June 2013. Silages were ensiled in bunker silos and treated with a formic acid-based additive (AIV-2 Plus; Eastman Chemical Company, Oulu, Finland: 760 g formic acid/kg, 55 g ammonium formate/kg) applied at a rate of 5 L/tonne of fresh forage. The silage harvested on 13 June 2013 was stored approximately 3.5 months before feeding. It was used from the end of September 2013 until January 2014.

Please cite this article as: Manni, K., et al., Effects of barley intake and allocation regime on performance of growing dairy bulls offered highly digestible grass silage. Livestock Science (2016), http://dx.doi.org/10.1016/j.livsci.2016.07.004