Meat Science 145 (2018) 461–468

Contents lists available at ScienceDirect

Meat Science

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

Feeding potentially health promoting nutrients to finishing bulls changes meat composition and allow for product health claims

Anna Haug[a,*], Stine Gregersen Vhile[a], Jan Berg[a], Knut Hove[a], Bjørg Egelandsdal[b]

[a] Institute for Animal and Aquacultural Sciences, Biovit Faculty, The Norwegian University of Life Sciences, P.O.BOX 5003, 1433 Ås, Norway
[b] KBM Faculty, The Norwegian University of Life Sciences, P.O.BOX 5003, 1433 Ås, Norway

ARTICLE INFO

Keywords:
Enriched bovine meat
Selenium
Vitamin D
Vitamin E
Vitamin K
Omega-3

ABSTRACT

Supplementation of feed for bulls with selenium (+50%), vitamin D_3 (+300%), vitamin E (+825%), vitamin K_3 (+325%) and omega-3 fatty acids (+120%) affected beef nutrient composition. Twelve bulls (½ year old) were randomly allocated to two dietary treatments; control (Con) or supplemented (Sup), and fed 170 days pre-slaughter at an amount of 1% of body weight. Daily gain and feed efficiency were equal in the two groups. Homogenate meat from left forequarter in the Sup group contained more selenium (+26%), vitamin MK4 (+123%), D (+197%), E (+318%), and had lower omega-6/omega-3 ratio (−24%) compared to Con meat. Sup meat fulfilled the requirements to be labelled by health claims and nutrient claims as: "A food item containing a significant amount of selenium, vitamin K and vitamin D". We suggest supplementation of cattle rations during the finishing period as a strategy to increase meat content of specific nutrients important to human health.

1. Introduction

Beef is an important dietary source of several essential nutrients such as protein of high biological value, iron, zinc, selenium, vitamins B_{12}, B_6 and K. The focus on the relationship between diet and health has led to increased interest in foods containing compounds that may affect health and diseases. The nutrient content in meat is affected by several factors, with composition of the animal diet as one important component. In Norway, a typical grass-land with only 3% cultivated land and limited potential for cereal and vegetable production, it is important to utilize the resources available to produce high quality food products from non-human food resources. The concerns for greenhouse gasses emitted by ruminants and the awareness for the environment are increasing. Due to this, meat and especially bovine meat, has lately been given much negative attention. Health aspects and environmental concerns of red meat intake has caused authorities in many countries to advice consumers to limit the intake of red meat (Australia - 2013, Brazil - 2014, Netherland - 2015, USA - 2015, Norway - 2016). Most consumers are knowledgeable of possible negative effects of red meat consumption on health such as risk of cancer and cardiovascular diseases (Alexander, Weed, Miller, & Mohamed, 2015; Oostindjer, Alexander, Amdam, Andersen, Bryan, Chen, et al., 2014), but results are conflicting and the subject is debated (Steppeler, Sødring, Egelandsdal, Kirkhus, Oostindjer, Alvseike, et al., 2017).

Supplementation of animal feed can be a cutting edge strategy to increase the intake of selected nutrients for humans. Earlier studies within this topic have primarily focused on the effect of different dietary fat sources on fatty acid composition in meat and eggs from monogastric species (Jiang et al., 2017a, b; Gjerlaug-Enger, Haug, Gaarder, Ljøkjel, Stenseth, Sigfridson, et al., 2015; Haug, Nyquist, Thomassen, Høstmark & Ostbye, 2014; Nyquist, Rodbotten, Thomassen & Haug, 2013; Shapira, Weill & Loewenbach, 2008) and in milk and meat from ruminants (Inglingstad, Skeie, Vegarud, Devold, Chilliard & Eknaes, 2017; Kliem, Humphries, Reynolds, Morgan & Givens, 2017; Bjorklund, Heins, DiCostanzo & Chester-Jones, 2014). Some studies report altered trace element- and vitamin content in products from monogastric- and ruminant animals (Han, Qin, Li, Ma, Ji &, Zhang et al., 2017; Jiang et al., 2017a, b; Burild, Lauridsen, Faqir, Sommer & Jakobsen, 2016; Gjerlaug-Enger et al., 2015; Hayes et al., 2015; Lawler, Taylor, Finley & Caton, 2004). In addition, others have made efforts to increase vitamin D in meat by exposing pigs to UVB light (Barnkob, Argyraki, Petersen & Jakobsen, 2016). However, to our knowledge, there is limited research on how diets supplemented with several different nutrients will affect nutrient composition and quality in bovine meat. When producing bovine meat, all efforts should be taken to obtain products that can benefit the health of meat consumers and offset the carbon footprints to the highest achievable degree.

The objective of the present study was to investigate the effect of

* Corresponding author.
E-mail address: anna.haug@nmbu.no (A. Haug).

https://doi.org/10.1016/j.meatsci.2018.07.015
Received 8 March 2018; Received in revised form 27 June 2018; Accepted 11 July 2018
Available online 19 July 2018

increasing the level of selenium (Se), vitamin K, vitamin D_3, vitamin E and omega-3 fatty acids in the feed for finishing bulls on nutrient concentration and quality of the meat. Selenium, vitamin K, vitamin D, vitamin E and omega-3 fatty acids all have an impact on human health. Especially for children and youth, and women in childbearing age, an adequate intake of these nutrients are essential. In the Western diet, intakes of Se, vitamin D and omega-3 fatty acids may not be optimal (Rayman, Winther, Pastor-Barriuso, Cold, Thvilum, & Stranges 2018; Odin, 2017; Simopoulos, 2002). It is well known that Se and vitamin E are crucial for defence against oxidative damage and other important biological functions in the body (Comitato, Ambra & Virgili, 2017; Hosnedlova, Kepinska, Skalickova, Fernandez, Ruttkay-Nedecky, Malevu et al., 2017). The influence of adequate intake of long chain n-3 fatty acids and of a low ratio of n-6/n-3 fatty acids on health parameters is well documented (Simopoulos, 2002; Christophersen & Haug, 2011). In Europe there is a gap between the current intake of vitamin D and recommended intake (*NNR* 2012). Insufficient vitamin D status is especially prevalent in children/adolescents in northern latitudes due to lack of adequate sunlight in wintertime (Mortensen et al., 2016; Aspell, Lawlor & O'Sullivan, 2017; Laird, O'Halloran, Carey, Healy, O'Connor, Moore, et al., 2017), and this is also relevant for elderly persons (*NNR* 2012). An established cause and effect relationship exists between the dietary intake of vitamin K and the maintenance of bone structure and blood coagulation (EFSA, European Food Safety Authority, 2009a, b). In addition, vitamin K deficiency has lately been mentioned as a contributing factor in pulmonary and cardiovascular diseases (Janssen & Vermeer, 2017; van Ballegooijen & Beulens, 2017; Cundiff & Agutter, 2016). The vitamin K status, however, has not been thoroughly studied.

Meat is generally rich in important nutrients, but the content varies (Oostindjer, Egelandsdal, Hovland & Haug, 2016). In the present study we have examined whether supplementation of nutrients to feed concentrate during the finishing period of bulls can be a strategy to increase meat content of specific nutrients important to health of many groups such as children, youth, women in childbearing age and elderly.

2. Material and methods

The experiment was managed in accordance with Norwegian legislation controlling experiments with animals (Forskrift om bruk av dyr i forsøk, 2015). The animal experiment complied with the ARRIVE guidelines, and was carried out in accordance to the U.K. Animals Act 1986 and the EU Directive 2010/63/EU for animal experiments. The guidelines were followed throughout the study. The animals were transported and slaughtered at a commercial abattoir (Nortura SA division Rudshøgda, Norway) according to approved procedures from the Norwegian Food Safety Authority.

2.1. Dietary treatments and experimental design

The dietary treatments were two different concentrate mixtures, control (Con) and supplemented (Sup). The concentrates were formulated to be similar with regard to energy- (NEL_{20}), protein- (CP, AAT_{20} and PBV_{20}), starch and NDF content (EAAP publication No. 130, 2011). The Sup concentrate was added extra selenium (Se-yeast), vitamin K_3, vitamin D_3, vitamin E as RRR-alpha-tocopheryl acetate, and Rape seeds and Camelina seeds (*Camelina sativa*) as source of n-3 fatty acids. The ingredient composition and chemical content of the two experimental concentrates are reported in Tables 1, 2 and 3.

All animals were fed the same roughage (silage of grass and clover) ad libitum during the whole experimental period. The dry matter content (DM) of silage was 402 g/kg, crude protein was 112 g/kg DM, neutral detergent fibre (NDF) was 527 g/kg DM, crude fat was 40 g/kg DM, and net energy (NEL_{20}) was 6.64 MJ/kg DM.

Twelve bulls of the Norwegian Red breed (NRF) from Animal Production Experimental Farm at the Norwegian University of Life

Table 1
Formulation of the feed concentrates (%)[1,2].

	Con	Sup
Barley	20.0	24.2
Oats	13.6	8.0
Wheat	5.5	11.5
Wheat bran	12.0	4.7
Rye	10.0	9.0
Corn gluten meal	5.0	5.0
Soybean meal	6.3	0
Rapeseed meal, heat extracted	0	12.5
Faba beans, white	10.0	7.1
Camelina seeds	0	1.8
Rapeseeds	0	1.6
Beet pulp	5.0	5.0
Sugar cane molasses	4.5	4.5
Limestone powder	0.85	0.72
Mono-calcium phosphate	0.70	0.48
Sodium chloride	1.2	1.2
Vitamin/mineral premix 1[3]	2.0	0
Vitamin/mineral premix 2[3]	0	2.0
Magnesium oxide	0.26	0.24
Live yeast premix[4]	0.5	0.5
Soybean oil	2.6	0

[1] Experimental concentrates: Con (Control): Standard concentrate for growing ruminants. Sup (Supplemented): Concentrate for growing ruminants enriched with added extra selenium, vitamin K_3, vitamin D_3, vitamin E as RRR-α-tocoferyl acetate, and n-3 fatty acids from Rape seeds and Camelina seeds.
[2] Produced by Vestfoldmøllene, Norgesfôr, Norway, February 2016.
[3] Produced by Vilomix, Hønefoss, Norway.
[4] *Saccharomyces cerevisiae* I-1077 2×10^9 CFU/kg diet.

Table 2
Composition of the experimental feed concentrates (per kg feed)[1].

		Con	Sup
Calculated from ingredients			
Dry matter	g	870	870
Net energy lactation (NEL_{20})[2]	MJ	6.0	6.0
Crude protein	g	149	149
AAT_{N20}[2]	g	107	104
PBV_{N20}[2]	g	2.0	1.0
Crude fat	g	46.4	44.7
Starch	g	314	321
NDF	g	175	175
Linoleic/α-linolenic acid		9.3	2.0
Calcium	g	11.4	11.2
Phosphorous	g	5.4	5.5
Magnesium	g	3.1	3.2
Sodium	g	4.8	4.9
Additions (per kg feed)			
Vit A	1000 IU	4	4
Vit B_1	mg	0	0
Vit B_2	mg	0	0
Vit B_6	mg	0	0
Vit D_3	1000 IU	1	4
Vit E as all-rac α-tocopheryl acetate	IU	30	30
Vit E as RRR-α-tocopheryl acetate	IU	0	500
Vit K_3	mg	0	10
Selenium as sodium selenite	mg	0.2	0.2
Selenium as Se-yeast[3]	mg	0.0	0.5
Cu	mg	15	15
Mn	mg	30	30
Zn	mg	70	70
I	mg	3.5	3.5
Co	mg	0.4	0.4

[1] Experimental concentrates: Con (Control): Standard concentrate for growing ruminants. Sup (Supplemented): Concentrate for growing ruminants enriched with added extra selenium, vitamin K_3, vitamin D_3, vitamin E as RRR-alpha-tocopheryl acetate, and n-3 fatty acids from Rape seeds and Camelina seeds.
[2] Calculated by using the NorFor system, EAAP, 2011.
[3] Alkosel® R397 from Lallemand Animal Nutrition.