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Effect of forage species on fatty acid content and performance of pasture-finished steers ☆

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ABSTRACT

Consumers are increasingly concerned with the form and quantity of fat present in the foods they consume. This is leading to a shift in the way food is produced. In particular the animal industry is increasing the number of organic and naturally finished meat animals rather than finishing them on grains. The objective of this study was to determine if different pasture compositions (i.e. grass only or grass legume mixtures) would impact the fatty acid (FA) meat composition of beef steers (*Bos taurus* L.). The pasture treatments were tall fescue [*Lollium arundinaceum* (Schreb.) S.J. Darbysh] only, or tall fescue combined with either red clover (*Trifolium pretense* L.) or alfalfa (*Medicago sativa* L. ssp. *sativa* L.). Beef steers (n = 9–10 per treatment) rotationally grazed each pasture treatment. Forage from treatments were different for crude protein (CP), *in vitro* true digestibility (IVTD) and the FA myristric (C14:0), palmitic (C16:0), palmitoleic (C16:1), stearic (C18:0), oleic (C18:1), linoleic (C18:2), and total FA. Steers grazing mixtures with either red clover (RC) or alfalfa (ALF) had greater average daily gains (ADG) than tall fescue only. Additionally, RC treatment steers had larger ribeye areas (REA) and greater finishing weights than those in the ALF treatment. However, the differences found between pasture treatments in FA concentration did not translate to any differences in the FA concentration of meat harvested from steers. Thus, it is concluded that although the pastures contained different FA concentrations, with the levels of legumes present, this does not influence the FA composition of beef.

1. Introduction

Recently, there has been a movement by both dietitians and the health conscious public to promote the consumption of healthier forms of livestock products. The current model of finishing animals, in particular beef, is to have these animals consume a high concentrate diet such as corn (*Zea mays* L.) or corn byproducts prior to slaughter. This system has led to meat products containing high amounts of saturated fatty acids (SFA) and an imbalance in the ratio between omega-6 and omega-3 ($n-6$:$n-3$) polyunsaturated fatty acids (PUFA). In western diets, the $n-6$:$n-3$ ratio approaches 15:1; however, a more appropriate level would be between 2:1 and 4:1 (Simopoulos, 1998, 2002). Meat from pasture-finished animals has greater amounts of $n-3$ fatty acids (FA) and also has the added benefit of having elevated levels of conjugated linoleic acid (CLA) (French et al., 2000). Both $n-3$ FA and CLA fats have been shown to lower the risk of heart disease, diabetes, and obesity as well as contain anticarcinogenic properties (Leaf & Kang, 1998; Sumeca & Miller, 2000; Weiss, Martz, & Lorenzen, 2004).

This information has led to many studies in dairy and beef cattle that compare the current feeding practices to feeding animals a forage diet (either pasture or conserved forages), or supplemental oils high in $n-3$ FA. Dairy cattle provided with high-quality forage diets, produce milk that has elevated levels of both $n-3$ and CLA (Dhiman et al., 1999). Similarly, beef cattle that were finished on pasture, rather than with traditional concentrate diets, also have meat products with improved nutritional quality (Dannenberger et al., 2005; French et al., 2000). When comparing high concentrate diets to those based on forages, the $n-3$ fraction of PUFA increased with a concomitant reduction of the SFA component found in the intramuscular fat (Dannenberger et al., 2005; French et al., 2000; Nürnberg et al., 2005; Poulson, Dhiman, Ure, Cornforth, & Olson, 2004). It was thought that adding a lipid source high in $n-3$ to the ration, such as linseed oil or fish oil, would allow the cattle to attain both high rates of gain and possess a higher proportion of PUFA (Scollan et al., 2001). Supplementing beef cattle with fish oil increased the amounts of long-chain PUFA and decreased the

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$n-6$:$n-3$ ratio, while linseed oil increased the amounts of short-chain (C18:3) PUFA (Scollan et al., 2001). Additionally, CLA concentrations in the meat of beef animals increased with increasing amounts of forage in the diet (French et al., 2000). However, supplementing livestock with CLA did not increase CLA in meat as much as grazing cattle on high-quality pasture (Poulson et al., 2004).

Although it has been established that forage-based diets alter the FA composition of meat and milk products, few studies have evaluated the effects of forage species on FA content in livestock products. It is known that the rumen is hostile to molecules that can be readily reduced. This is true for many of the unsaturated FA (UFA) found in the feed of ruminants, especially forages. This process is termed biohydrogenation where the unsaturated FA is reduced to a stable form as a saturated fatty acid (Harfoot & Hazlewood, 1997). This process is instrumental in the production of a class of FA compounds known as conjugated linoleic acids (CLAs) (Bauman, Baumgard, Corl, & Griinari, 2000). However, it is known that when ruminants consume different forage diets with nearly the same FA levels they produce milk or meat products that can have elevated UFA. This is thought to occur when ruminants are fed a forage diet high in clovers, in particular red clover, due to their polyphenol oxidase (PPO) activity. Dairy cattle fed red clover silage produced milk with greater amounts of linoleic and alpha-linolenic acid and lower amounts of saturated FA when compared to grass silage (Vanhataloa, Kuoppala, Toivonen, & Shingfield, 2007). Additionally, dairy cows fed red clover–grass silage produced milk with more PUFA and a lower $n-6$:$n-3$ ratio than those fed white clover (*Trifolium repens* L.)-grass silage (Steinshamn, Thuen, & Brenøe, 2007). Similarly, when lambs grazed pastures with high amounts of white clover and alfalfa, the intramuscular fat of the *longissimus thoracis* contained more PUFA than that of lambs that grazed perennial ryegrass or a "biologically diverse" pasture (Lourenco, Van Ranst, De Smet, Raes, & Fievez, 2007). Our objective was to determine if the FA concentrations in pasture-finished beef are altered by the addition of legumes to tall fescue pastures.

2. Materials and methods

2.1. Animal pretreatment and measures

Thirty crossbred Angus steers were obtained from a local livestock auction in January and February, 2007. The steers were overwintered on a diet of corn, distillers dried grain with solubles (DDGS), chopped hay, and limestone in a 65%, 25%, 9%, and 1% proportion, respectively. The diet was mixed through a Knight 3020 reel mixer (Kuhn North America, Inc., Brodhead, WI, USA) on a feed truck and fed in fenceline bunks at 08:00 daily. The grain's nutritional characteristics are shown in Table 1. Steers were moved to pasture treatments (described below) in late March or early April 2007, and grazing continued through July 30, 2007. Pasture treatments included tall fescue only, tall fescue + red clover, or tall fescue + alfalfa, hereafter referred to as TF, RC, ALF, respectively. The pasture treatments were located at New Franklin, MO (39° 1′ 2″ N, 90° 44′ 14″ W) on a Menfro silt loam soil (Fine-silty, mixed, superactive, mesic Typic Hapludalfs). The paddocks in each treatment were rotationally grazed throughout the duration of the experiment based on forage availability.

Each pasture treatment consisted of three main pastures which were broken into four paddocks for a total of 12 paddocks per treatment. The area of the TF and RC treatments totaled 3 ha while the ALF treatment was only 2.1 ha. To maintain the pastures in a vegetative state, cattle were moved to a new paddock on average every 3.2 days. When growth in some paddocks became excessive and mature the forage was removed by making silage. The forage removal was determined by both the plate meter values along with visually determining the maturity level of the forage. Silage harvests were made once for the TF and ALF treatments in late May, while the RC treatment was harvested in late June. In March, alfalfa stands began to grow quickly due to above normal temperatures, and steers were able to begin grazing this treatment on 29 March. However, March was followed by a cold April where temperatures were below freezing (Fig. 1). This killed much of the growth that occurred in March. Due to the weather conditions and associated decreased forage availability, steer placement on the RC and TF pastures was delayed by 7 and 14 days, respectively compared to the ALF treatment. On each of the three treatments 10 beef steers were used for the experiment. Cattle weights were recorded before placement on their respective pasture treatments in mid-March (ALF 419 kg SEM 7.74, RC 434 kg SEM 6.39, and TF 450 kg SEM 8.81), and when removed from the treatments July 31. Additionally, a 5 g subcutaneous fat sample was taken from the tailhead of each animal in early March. A surgical clip and scrub was performed on one side of the tail head. A 5 ml local block of 2% lidocaine was placed in the tail head area dorsal to the ischium and 4–6 cm lateral to the spine. A no. 20 scalpel blade was used to make a 3–4 cm vertical incision of the skin in the area. An Allis tissue forcep was used to grasp the subcutaneous fat and the scalpel was used to remove the sample. The skin was closed with one curciate suture using an absorbable suture material. These samples were analyzed for initial FA concentrations (analysis described below). This initial data was used to stratify cattle within treatments as well as provide a covariate for analysis. Natural or

Table 1
Concentration of crude protein (CP), neutral detergent fiber (NDF), digestible neutral detergent fiber (dNDF) as a proportion of NDF, and FA levels from the grain pretreatment.

Constituents	Concentrations
CP (g kg^{-1} DM)	149
NDF (g kg^{-1} DM)	142
dNDF (g kg^{-1} DM)	590
C14:0 (mg g^{-1} DM)	0.11
C14:1 (mg g^{-1} DM)	0.67
C16:0 (mg g^{-1} DM)	8.00
C16:1 (mg g^{-1} DM)	0.11
C18:0 (mg g^{-1} DM)	1.41
C18:1 (mg g^{-1} DM)	12.73
C18:2 (mg g^{-1} DM)	29.39
C18:3 (mg g^{-1} DM)	1.15
Total FA (mg g^{-1} DM)	53.57

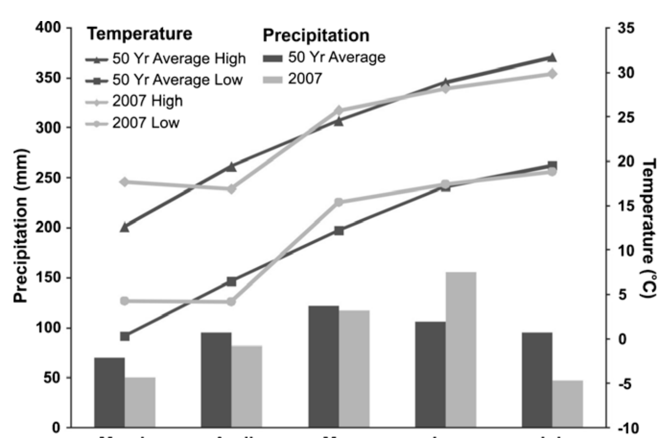

Fig. 1. Monthly total precipitation and average monthly high and low air temperatures at New Franklin, MO, From March to July 2007. Historic averages represent 50 years of data from New Franklin.