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Comparison of wheat- versus corn-based dried distillers' grains with solubles on meat quality of feedlot cattle

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ABSTRACT

A considerable amount of information has been generated on the feeding value and impact of corn dried distillers' grains with solubles (DDGS) on meat quality, whereas little is known about the effects of wheat DDGS on meat quality, and no direct comparison of these two sources of DDGS has been completed. The current study was conducted to examine the objective and subjective carcass and meat quality traits of cattle fed diets containing corn or wheat (20% or 40%) DDGS (DM basis) as compared to a standard barley-based finishing diet (control). In general, meat obtained from animals fed the barley-based control diet was slightly darker in colour (lower chroma and hue at 24 h, $P < 0.01$) and less tender (highest proportion of tough shears at 2 d and lowest proportion of tender shears at 20 d). Meat from corn DDGS was rated as more tender and palatable than control samples ($P < 0.05$), and 20% corn samples were rated better for beef flavour intensity ($P < 0.01$) and desirability ($P < 0.05$) than 40% corn DDGS samples. In contrast, meat from steers fed wheat DDGS showed intermediate characteristics between steers fed control and corn DDGS diets. Hence, feeding wheat DDGS had no negative effects, and feeding corn DDGS had some positive effects on meat quality characteristics of beef.

1. Introduction

Production of biofuels in North America as a renewable energy source has been increasing in an effort to lower dependence on foreign fossil fuels. As a result, western Canada is experiencing a significant increase in wheat-based ethanol production which in turn generates distillers' grains that can be used as livestock feed. Although wheat-based dried distillers grains with solubles (DDGS) represents an extensive feed base in western Canada, production of corn DDGS in the USA is even greater and may have the potential to be cost competitive with wheat DDGS in Canada. Compared with corn DDGS, however, there has been considerably less research conducted on the feeding value of wheat DDGS and its possible effects on carcass and meat quality.

Ethanol production utilizes the starch fraction of grains, concentrating the levels of other nutrients within DDGS. During the production of corn DDGS (dry matter (DM) basis), crude protein levels increase from 7.4–10% to 23–32% while fat levels increase from 3.5–4.7% to 9–12% (DDGS User Handbook, 2009; Klopfenstein, Erickson, & Bremer, 2008; Lemenager et al., 2006; Mustafa, McKinnon, & Christensen, 2000; Rasco et al., 1987; Spiehs, Whitney, & Shurson, 2002). In wheat DDGS, protein levels increase from 14% to 20–38% while fat levels increase from 1.6–2% to 2.5–6.7% (Mustafa, McKinnon, Ingledew, & Christensen, 2000; Philippeau, Martin, & Michalet-Doreau, 1999; Rasco et al., 1987; Schingoethe, 2006). Reed, Lardy, Bauer, Gibson, and Caton (2006) found that calves supplemented with 50% corn DDGS displayed no differences in live animal performance or carcass quality. However, some other preliminary studies from Kansas State University (data not published) suggest that levels of corn DDGS greater than 23% DM result in a decrease in carcass quality grade. This may reflect a reduction in marbling due to the lower starch content in DDGS as compared to corn. Meat colour may also be affected by feeding DDGS as Roeber, Gill, and DiCostanzo (2005) found that feeding 40–50% of DM as corn wet (WDG) or dry distillers' grains (DDG) resulted in declining colour stability of strip loins from finished Holstein steers. However, when corn DDGS was included at lower levels (10–25% DM), shelf life of steaks was maintained or slightly enhanced, with no effect on palatability. However, very little research regarding the impact of wheat DDGS on carcass and meat quality has been published (Beliveau & McKinnon, 2008).

The decision to include DDGS in cattle diets will be based on its cost, relative feeding value and the impact that it has on overall carcass value as compared to other feedstuffs. One advantage of including wheat DDGS in the diet of feedlot cattle may be its ability

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to improve the health properties of beef fat through an increase in levels of polyunsaturated fatty acids and an improvement in the profile of biohydrogenation products (Dugan et al., 2008). However, a higher level of polyunsaturated fatty acids in beef may increase its susceptibility to oxidation with possible effects on colour stability, rancidity and off-flavour development (Aalhus & Dugan, 2004). Calkins and Hodgen (2007) suggested incorporation of corn DDGS at high levels (50% DM basis) in dry rolled corn diets might be responsible for the development of liver like off-flavours in muscles from the hip and chuck, but Jenschke, James, Vander Pol, Klopfenstein, and Calkins (2007) did not find any increase in these off-flavours in cooked beef from yearling steers fed corn WDG plus solubles (0%, 10%, 20%, 30%, 40% and 50% DM basis).

Given the limited information available on the effects of wheat DDGS on beef quality and the lack of any direct comparison between the corn and wheat DDGS with regard to these parameters, the objective of the present study was to compare a barley-based control diet to the effects of including wheat or corn DDGS at 20% and 40% of DM on sensory attributes and quality of meat derived from finished steers.

2. Materials and methods

2.1. Animals, management and diet composition

This trial commenced in January 2008 at the University of Saskatchewan – Beef Cattle Research Station (SK, Canada). It involved 275 crossbred steers fed five different diets (55 animals per treatment) where corn or wheat DDGS was substituted for barley grain in the control diet at 20% or 40% of the dietary DM. The control diet consisted of 86.6% rolled barley grain, 5.7% supplement and 7.7% barley silage on DM basis. Comprehensive feed, animal performance and grade data (N = 275) are reported in a separate manuscript (Walter et al., submitted for publication).

From the 275 steers, 100 (20 per treatment) were selected for in-depth meat quality assessment. Four steers from each of the five treatments were selected on the basis of unshrunk live weight (645 kg target) at five separate slaughter dates. Selected steers at each slaughter date were loaded as a group (n = 20) at the University of Saskatchewan – Beef Cattle Research Station and transported (approximately 6 h) to the Agriculture and Agri-Food Canada (AAFC) – Lacombe Research Centre (LRC; AB, Canada). Upon receipt at AAFC – LRC, animals were held in lairage overnight with free access to water. Steers were slaughtered the following day at the AAFC – LRC abattoir with all animals being handled throughout the study under the guidelines established by the Canadian Council of Animal Care (1993).

2.2. Slaughter and sample collection

At the time of slaughter, final live weights were recorded and steers were stunned, exsanguinated and dressed in a simulated commercial manner. Following splitting of the carcass, hot side weights were recorded. Initial (45 min) pH and temperature were recorded on the left *Longissimus thoracis* (LT) between the 11th and 12th vertebrae (Visor Palm Pilot and Fisher Scientific Accumet Module using handspring software equipped with an Orion Ingold electrode; Udorf, Switzerland). Carcasses were then hot water pasteurized at 85 °C for 10 s followed by a warm water wash at 55 °C for 30 s and chilled at 2 °C (wind speed of 0.5 m/s) for 24 h.

Upon entry into the cooler, a T-type stainless steel thermocouple (30 cm) was placed into the right hip of the first three animals slaughtered from each diet (15 animals per kill). The thermocouple was placed approximately 15 cm above the aitch bone at a 45° angle to a depth approximately 2.5 cm from the femur. Deep-hip temperatures were monitored at 15 min intervals for a 24 h period (Hewlett Packard Data Logger HP34970A; Hewlett Packard Co., Boise, ID). Also, stainless steel thermocouples (10 cm) were placed into the right LT approximately 2.5 cm anterior to the 12th vertebrae of all animals (20 animals per kill) and temperatures were recorded every 15 min for 24 h using data temperature loggers (Mark III, MC4000; Sumaq Wholesalers, Toronto, ON).

2.3. Meat quality

At 24 h, the left and right carcass sides were weighed to determine cooler shrinkage losses. The left carcass sides were knife-ribbed at the Canadian grade site (between the 12th and 13th ribs) and the muscle surface exposed to atmospheric oxygen for 20 min. Full Canadian grade data were collected (grade fat thickness, estimated lean yield, ribeye area, and marbling score) along with objective colour measurements from three surface locations (CIE L^* (brightness), a^* (red–green axis), b^* (yellow–blue axis) values; Commission Internationale de l'Eclairage, 1978) using the Minolta CR-300 with Spectra QC-300 Software (Minolta Canada Inc., Mississauga, ON). Colour measurements were converted to hue [$H_{ab} = \arctan(b^*/a^*)$] and chroma [$C_{ab} = (a^{*2} + b^{*2})^{0.5}$]. Grade data including yield estimation and subjective estimates of marbling were assessed according to the Livestock and Poultry Carcass Grading Regulations (Canadian Food Inspection Agency, 1992) by a certified grader with extensive experience in a research environment. Numeric marbling scores (American Meat Science Association, 1990), the Canadian quality grade equivalents, and the corresponding USDA marbling terminology are summarised in Table 1.

A 24 h pH and temperature were also recorded in the left LT as it was removed from the carcass during carcass fabrication. Two steaks, each 2.5 cm thick, were removed from the posterior end. The first steak was comminuted using a Robot Coupe Blixir BX3 (Robot Coupe USA Inc.; Ridgeland, MS) and a subsample of 15–20 g was stored at −80 °C for further analysis. Raw steak weight was recorded on the second steak and a spear point temperature probe (10 cm) was inserted into the mid-point of the steak. The steaks were then grilled (Garland Grill ED30B; Condon Barr Food Equipment Ltd., Edmonton, AB) to an internal temperature of 35.5 °C, turned and cooked to a final temperature of 71 °C (Hewlett Packard HP34970 Data Logger; Hewlett Packard Co., Boise, ID). Total cooking time was recorded upon removal from the grill. Steaks were placed into polyethylene bags, sealed and immediately immersed in an ice/water bath to prevent further cooking. Steaks were then transferred to a 4 °C cooler and held for a 24 h period. Final steak weight was recorded the following day and six cores, 1.9 cm in diameter, were removed parallel to the fibre grain. Peak shear force was determined on each core perpendicular to the fibre grain using a TA-XT Plus Texture Analyzer equipped with a Warner–Bratzler shear head at a crosshead speed of 200 mm/min and

Table 1
Marbling and grade terminology.

Marbling term[a]	Marbling score	Grade
Devoid	100	Canada B1
Practically devoid	200	
Trace	300	Canada A
Slight	400	Canada AA
Small	500	Canada AAA
Modest	600	
Moderate	700	
Slightly abundant	800	Canada Prime
Moderately abundant	900	
Abundant	1000	
Very abundant	1100	

[a] United States Department of Agriculture marbling terminology.