EVALUATION OF FEEDLOT CATTLE HEALTH RELATIVE TO CARCASS QUALITY

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Evaluation of Feedlot Cattle Health Relative to Carcass Traits

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

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ABSTRACT

Jeske, Theresa Mae, M.S., Department of Animal Sciences, College of Agriculture, Food Systems, and Natural Resources, North Dakota State University, August, 2010. Evaluation of Feedlot Cattle Health Relative to Carcass Quality. Major Professor: Dr. Kasey Maddock Carlin.

The objective of this study was to investigate the effects of Bovine Respiratory Disease (BRD) and liver condemnation on beef carcass traits. Health treatment records for 2534 animals from a North Dakota feedlot were obtained and evaluated as evidence of BRD. Lung Lesions (n = 291) and lung condemnations (n = 1710) at slaughter where also evaluated as an indicator of BRD. Liver condemnation (n = 2298) at slaughter was also considered in the analysis. Traits measured were hot carcass weight, USDA Quality Grade, USDA Yield Grade, ribeye area, marbling and 12th rib fat thickness. All cattle were evaluated by experienced feedlot personnel and treated according to a health protocol utilized by the feedlot. The incidence rate of BRD was observed as affecting 3.40% of the feedlot population. USDA Quality Grade ($P = 0.001$) and hot carcass weight ($P = 0.07$) were decreased for cattle treated for BRD. Cattle with lung condemnation at slaughter had a tendency for lower hot carcass weights. Conversely, marbling ($P = 0.04$) and 12th rib fat thickness ($P = 0.04$) was increased for cattle with lung condemnations at slaughter. Ribeye area was decreased ($P = 0.004$) for cattle with liver condemnations at slaughter and cattle with liver condemnations had increased USDA Quality Grades ($P = 0.03$). The presence of any one particular measurement did not significantly affect all carcass traits measured; however, the relationships between health parameters and carcass traits may be considered in future research in specific carcass traits.

Key words: bovine respiratory disease, cattle, carcass, health, feedlot

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1. ANIMAL HEALTH IMPLICATIONS ON BEEF QUALITY

Introduction

Bovine Respiratory Disease (BRD) is the leading cause of cattle illness in the United States and affects 14.4 % of cattle placed in feedlots. Average cost of treatment for BRD is among the highest of all production inputs and varies from $11.09 to $16.26 per sick animal (USDA APHIS, 2001). Bovine Respiratory Disease is a complex of diseases characterized by many types of infection, each having its own causes, clinical signs, and economic implications which results from interactions between stress, host immunity and infectious pathogens (Ellis, 2001).

Vaccination is one of several health management practices available to feedlot operators to decrease the risk of BRD and its overall impact on animal performance in the feedlot (USDA APHIS, 1995). Vaccinations against BRD need to be given at least 14 days prior to the initial stressor in order to be effective against respiratory pathogens. Currently there are no uniform vaccination strategies among cow-calf producers in the United States. Data collected by the United States Department of Agriculture National Animal Health Monitoring System (NAHMS) has indicated that one in three operations typically vaccinate calves, between birth and weaning, for respiratory pathogens (USDA APHIS, 2010). A study conducted by the NAHMS in 2007-2008 found that prior to sale, 42.1 % of calves were never vaccinated while 24.9% and 29.0 % were vaccinated once and twice respectively prior to sale to a feedlot (USDA 2008).

Administration of antibiotics (treatment) for BRD varies among feedlots by the number of treatments administered, the products administered, and the size of the feedlot. Schneider, et al. (2009) found that the average day of first treatment was day 40 in the feedlot and that by day 55, 75% of cattle received treatment for BRD. As number of treatments increased the total value loss associated with performance and carcass traits increased. Cattle with 1, 2, 3, or more treatments were found to have a decline in carcass and performance value of $23.23, $30.15 and $54.01, respectively. Cattle with subclinical BRD may be observed to have lung lesions at harvest without any documentation of treatment by feedlot personnel. Subclinical BRD may be associated with a greater loss in profit to the feedlot owner as cattle remain chronically ill over an extended period without any treatment, increasing performance loss. These cattle typically are missed by pen riders who are looking for specific symptoms of respiratory illness and as a result are not identified as unhealthy and are missed by analysis if only utilizing health records from the feedlot to identify them. It is important to identify the chronically ill cattle, as well as, the cattle with acute, aggressive BRD. Therefore, the primary objective of this study was to evaluate animal health effects on carcass quality through the utilization of treatment records and presence of lung lesions at slaughter.

Overview of the Beef Industry

Review of Beef Quality Audits

The original 1991 Beef Quality Audit was conducted to serve as a benchmark and evaluation tool to determine which areas of beef production required improvement to better satisfy the expectations of customers (Lorenzen et al., 1993). Even though the USDA Market Consist Report conducted in 1974 was said to provide the benchmark for future evaluations, the use of Continental breed cattle in crossbreeding systems and changes to consumer wants required new benchmarks be set. Surveys were conducted in packing plants to measure production related quality defects and to evaluate carcass grade information obtained in the carcass cooler. A recommendation was made following the BQA of 1991 to conduct such audits every 4-5 years to keep producers knowledge current with changes in the beef industry and determine necessary areas of improvement. The 1995 BQA was conducted within this time period and monitored the progress made by producers in the years following the 1991 audit and to make suggestions to producers that would help improve beef quality (Lorenzen et al.,1993; Boleman et al., 1998).

The 1991 Beef Quality Audit was conducted in 28 packing plants over a three month period. The plants were selected to represent a certain geographical region with a minimum slaughter capacity of 1,000 head per day and collectively represented 80% of all inspected meat at the time. Data collected during this audit included observations from both the slaughter floor and in the carcass cooler. Data was collected from carcasses moving at chain speed and included observations from various evaluators including hide defects, viscera condemnation, presence of bruising, horns and mud, sex determination, breed type and yield grade and quality grade factors (Lorenzen, et al., 1993).

Upon evaluation of the carcass traits, it was found that USDA yield grade had decreased when compared to the 1974 report. Average carcass traits for the 1991 audit were listed as follows: UDSA yield grade, 3.1; carcass weight, 344.7 kg; adjusted fat thickness, 1.5 cm; longissimus muscle area, 83.4 cm^2; and kidney, pelvic and heart fat percentage, 2.2. Of the carcasses sampled, the majority were classified in the YG 3 and YG 2 categories at 39.6 and 33.9 % of the population respectively. Longissimus muscle area increased by 7.1 cm^2 and hot carcass weight increased by 36.8 kg over the 1974 Market Consist Report. However, 20.5 % of the carcasses were outside of the desired weight range of 294.8 to 385.6 kg established by Lochner in 1992. A change in fat growth patterns was noted as a possible result of the addition of Continental European cattle breeds. Excessive amounts of subcutaneous fat, a decline in average marbling score from Small-plus to Small-minus, and heavier carcass weights may also be a result of crossbreeding these alternative Continental genetics (Lorenzen, et al., 1993).

The National Beef Quality Audit- 1995 was conducted to monitor the progress in quality since the 1991 audit and to issue further advice to beef producers in regard to improving beef quality, consistency and competitiveness in the markets. The NBQA-1995 evaluated twenty nine federally inspected plants. A breakdown of average carcass traits were as follows: USDA yield grade, 2.8; carcass weight, 339.2 kg; adjusted fat thickness, 1.2 cm; longissimus muscle area, 82.6 cm^2; and kidney, pelvic and heart fat, 2.1%. When compared to the NBQA-1991, carcasses in the 1995 audit had decreased USDA yield grade, adjusted fat thickness, and kidney, pelvic and heart fat. The 1995 audit also indicated a drop in percent of cattle above the Choice quality grade and marbling scores, including marbling scores which had decreased from Small^{24} to Small^{06}. The percent of cattle outside the established carcass weight boundaries had decreased from 20.5% in 1991 to 15.2% of carcasses in 1995 (Boleman, et al., 1998).

In the five years following the 1995 NBQA, a resurgence in beef demand, an increase in the number of branded beef programs, an abundant supply of cheaper feedstuffs, and the formation of the Beef Quality Assurance program influenced change within the beef industry. These factors may have brought better awareness of beef quality to producers thus impacting the quality and consistency of their products. The 2000 NBQA was conducted to assess the state of the industry in terms of quality and consistency and also monitoring areas that need improvement and tracking the progress made from previous audits. The average carcass traits were found as follows: USDA yield grade, 3.0; carcass weight, 356.9 kg; adjusted fat thickness, 1.2 cm; longissimus muscle area, 84.5 cm^2 and kidney, pelvic and heart fat, 2.4% (McKenna, et al., 2002). The 2000 Beef Quality Audit found an increase in longissimus muscle area, carcass weight, kidney, pelvic and heart fat and yield grade while adjusted fat thickness remained the same.

The discovery of a cow infected with Bovine Spongiform Encephalopathy within the United States dominated policy change within the beef industry between the 2000 and 2005 Beef Quality Audits. Age verification, animal origination, and offal restrictions were added to packing plant operations to combat the negative backlash of this virus. Exportation regulations were changed to exclude cattle over 30 months of age in an attempt to exclude cattle infected with BSE and save the export market from complete disintegration. The average carcass traits in 2005 were found as follows: USDA yield grade, 2.9; carcass weight, 357.7 kg; adjusted fat thickness, 1.3 cm; longissimus muscle area, 86.9 cm^2; kidney, pelvic and heart fat, 2.3% and USDA quality grade, Select^{90} (Garcia et al., 2008). The ten years preceding the 2005 quality audits longissimus muscle area and hot carcass weights continued to increase while adjusted fat thickness and kidney, pelvic and heart fat remained steady. Implying that cattle feeders have adapted their feeding programs and genetic selection to receive the greatest amount of product from their livestock while maintaining overall quality for consumers. The Beef Quality Audit is a tool producers can utilize to ensure their production methods produce a product that satisfies the consumers' demands.

Overview of Beef Quality Measurements and the Economic Impact of Beef Quality

In today's livestock market, carcass quality is the basis of marketing cattle. Cattle are evaluated using a set of standards to compare the overall carcass quality to that of a given animal. If a carcass is higher or lower quality when compared to the set standard the producer will receive a premium or discount from the packing plant (Feuz et al., 2009). Many different marketing options are available to producers. Depending upon the program, certain types of cattle may receive premiums for being lean or differences in the production of the animal, such as natural, organic or "conventionally" raised. The majority of cattle are marketed as "conventionally grown" which means the producer may utilize technology and various feeding programs while raising the cattle. For example, "conventionally" fed cattle may receive growth implants and be fed genetically modified corn, whereas other markets may emphasize production programs, breed characteristics or quality standards such as certified organic, Certified Hereford Beef, or Laura's Lean Beef. In 1965, the United States Department of Agriculture defined the terms "quality" and "quality grade" as referring to the palatability-indicating characteristics of lean (USDA, 1965). The terms were later specified to include "those factors which we associate with tenderness, juiciness and flavor or overall palatability" of beef at the National Livestock Feeders Association Annual Conference in 1973 by J. C. Pierce (as cited in Smith et al., 1987). These two definitions indicate that cattle ranked by quality grade are of a given value to the consumer.

As the overall quality grade of a beef carcass increases, the probability of satisfaction in taste and texture properties increases for the consumer (Savell, 2007). The USDA quality and yield grades also help relay information to producers on consumer preferences for beef, allowing producers to plan their production and marketing programs to try to meet these standards. Quality grade is determined by evaluation of maturity, marbling and firmness of the ribeye muscle as these factors have been shown to contribute to overall palatability (Savell, 2007). Maturity has an influence on beef tenderness because as cattle age, a greater amount of connective tissue and collagen are present within the muscle fibers. Degree of marbling is believed to have the most impact on juiciness, flavor and overall like of a meat product (Savell et al., 1987, Neely et al., 1998, Killinger et al., 2004). Studies have indicated that consumers prefer Prime, Choice and Select quality grade carcasses for different reasons. Depending on their geographical location, consumers have different preferences and abilities to determine the quality grade of a steak they are consuming and will impact their purchases of meat products (Savell et al., 1987, Smith et al., 1987).

Carcass maturity is evaluated based on skeletal and lean indicators. There are five maturity categories in which beef carcasses are sorted into. Labeled as letters "A" through "E", the maturity of the animal increases with the letter. For example, an "A" maturity carcass is from an animal up to approximately 30 months of age, and would include quality grades Prime, Choice, Select and Standard. This is the maturity group in which a majority (97.1 %) of United States cattle are marketed according to the most recent Beef Quality Audit (Garcia et al., 2008). The largest influence of maturity on price is between cattle in "B" and "C" maturity categories. At the approximate age of 42 months of age and up, carcasses are categorized into either "C, D, or E" maturity and can only be considered under the three quality grades of Commercial, Utility and Cutter, thus decreasing the value of the carcass. According to the USDA Carlot Report for the week ending on May 31, 2010, the discount between cattle from "B to C" maturity was $16.84 with Choice B maturity cattle valued at $148.40 per hundred weight and C maturity cattle valued at $131.56. The percent ossification of cartilage and the color and texture of lean are areas evaluated to determine maturity of the animal (Savell et al., 2007). Maturity of the carcass can be estimated by the hardness of the chine bones, shape and color of the rib bones, and fusion of the sacral vertebrae (Tatum et al., 2001). In a young maturity "A" carcass, soft porous chine bones will terminate with cartilage buttons present at the dorsal vertebrae. Rib bones on a young carcass are narrow and red, with distinct separation between the sacral vertebrae. In older animals, the chine bones become hard and white, the rib bones are wide and flat and the sacral vertebrae will be fused together. Age or maturity of an animal can also be indicated by the color and texture of the ribeye surface. An advanced maturity carcass will appear dark red in color and coarse textured while a young carcass is light red in color with fine texture. This is a result of increased myoglobin levels in the meat and a greater ratio of connective tissue in older animals when compared to young animals (< 30 months of age; Aberle et al., 2001).

Marbling, or intramuscular fat distributed within the perimysium, is evaluated at the cut surface of the ribeye, *M. longissimus thoracis* muscle, at the 12^{th} and 13^{th} rib interface (Aberle et al., 2001). Degrees of marbling are categorized from greatest to least and are Abundant, Moderately Abundant, Slightly Abundant, Moderate, Modest, Small, Slight, Traces and Practically Devoid. Figure 1 indicates how USDA Quality Grade is established using the maturity categories (x-axis) and marbling levels (y-axis).

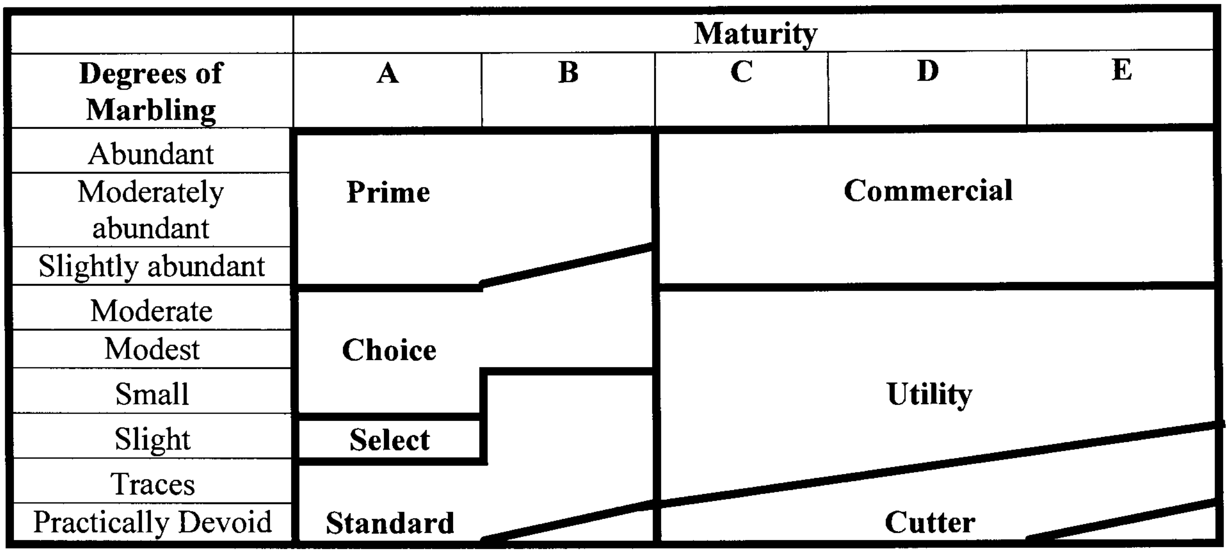

Figure 1. USDA Quality Grades

As amount of marbling increases, overall palatability increases and the palatability variability decreases. Savell et al. (1987) indicated that steaks with a greater degree of marbling, including Slightly Abundant, Moderate, Modest and Small, allowed consumers the option of cooking steaks to "medium well" or "well" degrees of doneness while still maintaining an acceptable eating experience. Steaks with lower marbling scores, including Slight and Traces, were more likely to offer a poor eating experience as there wasn't enough marbling present to prevent it from becoming a tough and dry when over cooked. This implies that marbling is an "insurance" that consumers are more likely to have a positive eating experience when marbling is increased within a steak (Savell et al., 1987). The more desirable an eating experience, the more consumers will pay for a steak with more marbling. The price difference between a Choice and Select carcass during the week ending on May 31, 2010 was $6.00 dollars per hundred pounds of product (USDA AMS, 2010). This choice-select "spread" can vary greatly and can be as high as $30/cwt or more.

Another aspect utilized to market cattle is the USDA Yield Grade. Yield Grades identify the amount of saleable retail cuts that may be obtained from the carcass. Also known as the cutability of the carcass, it includes the overall yield of boneless, closely trimmed retail cuts from the round, loin, rib and chuck of a carcass (Tatum et al., 2001). Yield Grades are identified as numbers 1 through 5 with YG 1 carcass having the greatest yield of retail product and YG 5 having the lowest yield of retail product. To determine the numerical yield grade value four measurements are taken: the amount of external fat cover, the amount of kidney, pelvic and heart fat, the area of the ribeye muscle and the hot carcass weight. The amount of external fat is measured as the amount of fat thickness over the ribeye muscle at the 12th and 13th rib interface and in terms of tenths of inches. The amount of kidney, pelvic and heart fat evaluates the weight of fat within the body cavity as a percent of the hot carcass weight. The area of the ribeye muscle cross-section is measured at the 12/13th rib interface. The area is typically measured using a carcass grid or subjectively evaluated to determine the square inches of muscle. The hot carcass weight is typically given to the evaluator; however, it can be estimated as 63% of the live weight. The Yield Grade (YG) is then calculated using a regression equation of YG = 2.5 + (2.50 x fat thickness, in) + (0.20 x % kidney, pelvic and heart fat) + (0.0038 x hot carcass weight, lb) – (0.32 x area of ribeye, in^2) (Tatum et al., 2001). The evaluation of YG is then utilized along with quality grade to establish price relative to the animal carcass according to its overall quality. An example of a typical price grid is shown below within Table 1. The price per hundred weight (cwt) is found by taking the base price for the day and either adding or subtracting the premium or discount received based on the corresponding quality grade and yield grade of the animal. The adjusted price per hundred weight is then multiplied by the carcass cwt to reach the total value of the animal.

Table 1. Example Price Grid ($/dressed cwt.)

	Yield Grade				
Quality Grade	1	2	3	4	5
Prime	11.00	9.00	6.00	-14.00	-19.00
Choice	5.00	3.00	Base	-20.00	-25.00
Select	-1.00	-3.00	-6.00	-26.00	-31.00
Standard	-11.00	-13.00	-16.00	-36.00	-41.00

Bovine Respiratory Disease

Physiological Effects and Characteristics of BRD

Bovine Respiratory Disease (BRD) is the leading cause of illness and death to U.S. feedlot cattle with 14.4% of cattle entering the feedlot being diagnosed with this disease (USDA APHIS, 2001). Decreased average daily gain, increased treatment and labor costs and a decrease in carcass value at the slaughter plant are all areas of production that are negatively impacted by this disease (Snowder et al., 1999). The BRD complex, also known as shipping fever, is triggered by a period of stress which weakens the immune system, allowing pathogens to invade the body. Stressors include weaning, transport, commingling, nutritional changes and general cattle handling (Schneider et al., 2009). Environmental risk factors that predispose cattle to the increased risk of disease include climate changes, ambient temperature, air quality, stocking rate, humidity, ventilation and shipping distance (Snowder et al.,2006).

Because the body has been immunocompromised, pathogens invade the animal and cause damage to the upper air ways, and cilia. Microbial causes for BRD are viral including: *bovine respiratory syncytial virus* (BRSV), *parainfluenza-3 virus* (PI-3), *infectious bovine rhinotracheitis* (IBR), and *Bovine Viral Diarrhea*; and bacterial including: *Mannheimia haemolytica, Pasturella multocida, Histophilis somus, and Mycoplasma bovis* (Ellis, 2001). Within 7 to 21 days following a stressful event, symptoms may be seen indicating respiratory illness. Physiological effects of Bovine Respiratory disease include depression, fever, increased respiratory rate, nasal discharge, droopy ears, hunched back, anorexia, isolation from others and ocular discharge. Signs of respiratory illness are commonly a sign of acute interstitial pneumonia and following the onset of symptoms offer a poor prognosis to reverse any damage that may have occurred including lung damage.

Infection of and Variation in Bacteria Presence within the Respiratory Tract

Due to the multiple risk factors of Bovine Respiratory Disease complex multiple vaccinations are administered in an attempt to combat any form of the disease. Following the initial stressor, the pathogens invade the respiratory tract and allow bacteria to cause further damage to the lung tissue (Baker, 2004). The bacterial risk factors including *Pasturella multocida, Mannheimia haemolytica, Histophilis somni* and *Mycoplasma bovis*, are present in the cattle population, environment and are naturally found in the respiratory tract. Following a respiratory mortality, it is not uncommon for a necropsy to find all four bacteria present in the respiratory tissues. These bacteria work in sync with each other and may become the infective agent following the presence and immune response of a viral agent.

Mannheimia haemolytica is the most aggressive bacterial pathogen in BRD of cattle postweaning. *M. haemolytica* is commonly found within the tonsillar tissue draining from retropharyngeal lymph node. Typically this bacteria is impossible to isolate from a nasal swab of healthy unstressed cattle, however, the isolation rate increases as animals are stressed. Upon weakening of the immune system, the frequency of *M. haemolytica* from lungs of fatal BRD cases is present (Mosier, 1997). Upon infection of this bacterium, a vigorous inflammation immune response occurs. *M. haemolytica* is the principal organism which causes lung damage, pneumonia and even death (Baker, 2004). *M. haemolytica* multiplies within the lung and releases a protein exotoxin, leukotoxin (Czuprynski et al., 2009). Upon replication of *M. haemolytica*, the leucotoxin lyses with responding leucocytes to the immune reaction and causes further lung damage and cell apoptosis (Baker, 2004). There are several inactivated vaccinations (killed) available to producers which can be combined with other live vaccines to aid protection against *M. haemolytica* (Baker, 2004).

Pasturella multocida is reported as being present in many fatal cases of BRD. Its presence in young cattle, especially dairy calves, results in enzootic neonatal calf pneumonia. When present in weaned calves, these bacteria cause pneumonia following a period of stress. *Pasturella multocida* can be isolated in normal healthy calves at rates of 20-60% of total bacteria from nasal secretions and deep pharyngeal collections. Following challenges from the presence of disease, animal handling, environmental or nutritional changes, moderation of the immune system occurs allowing the body to be more susceptible to disease. Calves suffering from respiratory disease have an isolation rate about twice as high as normal calves (Griffin et al., 2010). When compared to other bacterial species, *P. multocida* is generally less pathogenic and requires more organisms to initiate a primary infection. In feedlot cattle and dairy calves, *P. multocida* is most often associated with subacute to chronic bronchopneumonia and may cause fibrinous bronchopneumonia (Mosier, 1997).

Histophilis somni, also known as *Haemophilis somnus*, resides in the nasopharyngeal region and prefers to colonize within the lower respiratory tract. The isolation rate in normal, healthy calves has been found to be 15-50% in a typical population and is higher in feeder cattle showing clinical signs of BRD. *Histophilis somnus* is responsible for several disease manifestations including fibrinopurulent bronchopneumonia, abscessing laryngitis, as well as, being the precursor to many other diseases associated with respiratory diseases (Griffin, 2010). Presence of *H. somni* within the lung tissue is identifiable by the formation of thrombi within the blood vessels and an increased permeability of endothelium tissue of the lung. The isolation rate is inversely related to the geometric mean of *H. somnus* antibody titer for groups of newly received cattle. Sufficiently timing immunization before weaning and other stressors may be key to minimizing the effects of *Histophilis* on cattle. A killed bacterin vaccination is available, however, immunity is not long lasting but, has shown some success to aid protection in the face of an outbreak (Baker, 2004).

Mycoplasma bovis can play a role in enzootic pneumonia with or without associated symptoms of diseases which makes it difficult to detect. This bacterium may act as a primary pathogen following a stressful activity. *M. bovis* has been difficult to detect by use of a nasal swab, however, the bacteria's movement can be tracked deep within the respiratory system. Infected cattle pass the bacteria to other animals and may be present without exhibiting any symptoms of disease for their entire life. Dam to offspring transmission occurs through bacterium found in the mammary glands and is ingested by young calves. Aerosolized or inhaled milk during suckling is also an apparent route to the respiratory tract. Upon entering the respiratory tract, *M. bovis* can transfer to the circulatory system and be found within other tissues within a day and persist for more than a week. *Mycoplasma bovis* may be isolated at an increased rate following a stressor, however, under healthy circumstances isolation rates may vary from nonexistent to above 90% (Griffin, 2010). It is important to note that these bacteria may invade the animal at the same time or allow bacteria to invade following an immune response due to another bacterial or viral invader.

Viral components of BRD, including BVD, IBR, PI-3 and BRSV, compromise the cellular function and structure of terminal bronchi and alveolar walls. Inflammation of the terminal bronchi and alveolar walls leads to plugging of the airways and is partially responsible for the soft nonproductive cough which may develop due to respiratory infection (Briggs et al., 1991; Daoust et al., 1989; Engen, 1991). Bovine Viral Diarrhea Virus (BVDV) is readily shed from excretions and secretions of the body including nasal discharge, tears, saliva, urine, feces, milk and semen (USDA APHIS, 2007). BVDV is typically found to affect newly weaned cattle and cause severe upper respiratory tract damage. It can be spread amongst individuals through embryo transfer, rectal exams, artificial insemination and environmental contact (USDA APHIS 2007). Pasturella Influenza-3 (PI-3) is typically a problem in yearling cattle which causes severe upper respiratory tract damage (Pringle et al., 1988; Yates et al., 1983; Ryan et al., 1993). The most important role of PI-3 is that it predisposes the respiratory tract to subsequent infection by other viruses and bacteria especially *P. haemolytica*. In cases which environmental and managerial practices are suboptimal, PI-3 may become and initiator of respiratory tract disease (Wikse and Baker, 1996). The causative agent of IBR is Bovine Herpesvirus-1 (BHV-1). Aerosol exposure to BHV-1, PI-3, or BVDV facilitates lung infection by a usually noninfectious dose of *P. haemolytica* or *P. multocidia* resulting in fibronous or bacterial pneumonia (Briggs et al., 1991; Daoust et al., 1989; Engen, 1991). Bovine Respiratory Syncytial Virus infections associated with respiratory illness most commonly occur in young animals but are capable of causing sporadic cases of the disease in adult animals. Natural infections and experimental studies have indicated that passively derived antibodies do not prevent BRSV infections in calves (Wikse and Baker, 1996). Bovine Respiratory Disease is an extremely complex disease which can be caused by environmental, managerial, and viral properties.

Effects of BRD Treatment on Performance

Several studies have been conducted to evaluate the effect of respiratory illness on feedlot performance and carcass quality. Upon identification of respiratory illness, cattle are typically pulled from the feedyard and placed in a hospital pen. Temperature and further physical evaluation normally occurs to help determine the route of treatment for the animal. It has been observed that treated cattle have decreased ADG as the number of treatments increases (Gardner et al., 1999; Thompson, et al., 2006; Schneider, et la., 2009). Roeber et al. indicated that cattle treated two or more times had a 12% lower average daily gain through the initial implant period (67 days from receiving date) when compared to untreated cattle. However, over the entire feeding period, cattle treated one time had a higher average daily gain compared to healthy cattle (Gardner et al., 1999; Roeber et al., 2001). As number of treatments increased, a decrease in ADG may be due to a change in diet and number of feedings that occur. Sick animals typically are fed a ration lower in net energy content when placed in the hospital pen and have an increase in overall days on feed by 5.1 days (Thompson et al., 2006). The alteration in diet results in fewer productive days, increasing the days on feed when compared to their pen mates. Loss in production becomes more severe as the number of trips to the hospital pen increases (Larson, 2005). Another effector on average daily gain could be the amount of feeding bouts taken during the day. Sowell et al. (1999) indicated that animals diagnosed with BRD spent less time and made fewer trips to the feedbunk for several days prior to being clinically identified as ill.

An alteration in diet and presence of illness has also been found to impact carcass quality. Healthy cattle have been found to have more desirable estimates for all carcass traits including heavier carcasses with greater amounts of fat and muscle (Schneider et al., 2009). Treated cattle have advanced skeletal and lean maturity when compared to healthy cattle (Gardner et al., 1999). Schneider et al. (2009) determined that as the number of treatments increased, the hot carcass weight and marbling decreased (Schneider et al., 2009). When comparing one treatment with multiple treatments, no differences were found in ribeye area and physiological maturity, however, cattle treated once had a heavier carcass with a higher dressing percent, and internal and external fat measurements (Gardner et al., 1999). Schneider et al. (2009) indicated that greater than 71% of healthy cattle graded Choice or better while treated cattle significantly decreased the percent graded Choice or better to 57% of the population. Cattle with multiple treatments where 5 times more likely to be in the Standard quality grade when compared to healthy cattle (Schneider et al., 2009).

Lung Lesions

Development of Lung Lesions

Following the primary infection, damaged lungs may be infected by secondary bacteria which invade and proliferate. These bacteria include *Mannheimia haemolytica, Pasturella multocidia, Histophilis somni* and *Arcanobacterium pyogenes.* Bovine Respiratory Syncytial virus and *Mannheimia haemolytica* are most frequently isolated as the organisms that cause shipping fever. Following a stressor and infection by other pathogens this bacteria invades the lung and proliferates causing further lung damage (Baker, 2004).

Lung Lesion Effects on Cattle Performance

The exact mechanism of action for the formation of lung lesions is unknown. However, it has been determined that lung lesions and presence of active bronchial lymph nodes have a negative impact on overall performance and carcass quality at slaughter. Cattle that have never been diagnosed with respiratory disease were found to have lung lesions in 37% of the population while, 48% diagnosed with respiratory disease had lung lesions (Gardner et al., 1999). Cattle with lung lesions had a lower dressing percent when compared to cattle without lung lesions. Cattle with healthy lungs had heavier carcasses, more internal and external fat with a tendency for a larger longissimus muscle area. Lung lesions were found to have decreased final live weights and reduced average daily gain by 11%. Bronchial lymph node activity was also found to decrease performance of cattle. Cattle with no present lymph node activity tended to have a higher marbling score at slaughter. Active bronchial lymph node presence resulted in an 18% lower average daily gain than inactive lymph nodes, indicating that these cattle never compensated for performance lost during the period of morbidity. Cattle with both lung lesions and active bronchial lymph nodes tend to have a higher percent of cattle within the Standard quality grade at the expense of Choice and Select cattle. Although no maturity differences were found among lymph node activity, cattle with inactive bronchial lymph nodes were found to have a greater dressing percent and hot carcass weight increasing the value of cattle sold (Gardner et al., 1999). Thompson et al. (2006) evaluated cattle in South African feedlots and found cattle with lung lesions had a decreased average daily gain of 88 grams during the finishing period and increased days on feed by 5.5 days. Schneider et al. (2009) found there were no significant effects among cattle with and without lung lesions in terms of performance and carcass quality; however, cattle with active bronchial lymph nodes had a decreased average daily gain, hot carcass weight and final weight when compared to healthy cattle. Investigators have noted differences among performance traits in terms of the presence of lung lesions; this discrepancy makes it important to note that overall BRD cannot be defined by lung lesion presence alone. The severity of respiratory illness, differences in healing rates and fibrin contraction may result in varying severity of lung lesions seen at slaughter.

Liver Abscess Formation and Effects on Production and Carcass Quality Traits

Liver abscesses are present in 12-32% of feedlot cattle and represent 46% of total liver condemnations in slaughtered beef cattle (Brink et al, 1990; Nagaraja and Chengappa, 1998). Commonly associated with cattle on an aggressive feeding program, the formation of a liver abscess occurs following rumen acidosis or upset which weakens the internal rumen mucosal lining (Epperson, 1999). As a result of an impaired mucosal wall, bacteria can readily enter the bloodstream and pass to the liver. *Fusobacterium necrophorum* is the bacteria implicated to cause liver abscesses, as well as, foot rot (Nagaraja and Chengappa, 1998). Liver abscesses vary in thickness and can range in size from that of a pinpoint to over 15 cm in diameter. The liver accounts for approximately 2% of total carcass weight and liver abscesses has become an important issue as indicated by the 1995 National Beef Quality Audit (Nagaraja and Chengappa, 1998). Cattle with liver abscesses have been observed to have a decreased dressing percent, fat thickness, slaughter weight and carcass weight (Brink et al., 1990). The decrease in dressing percentage may be an indicator of excess carcass trim due to the adhesion of abscesses to the diaphragm and surrounding organs. Cattle with liver abscesses also are a liability to the packer as an accidental puncture of an abscess, causing contamination by exudate, will interrupt the flow along the slaughter floor chain (Nagaraja and Chengappa, 1998). Liver abscesses have also been found to cause a major economic liability to the production traits at the feedlot. Cattle with severe liver abscesses have a decrease in carcass weight gain as a result of a decrease in dry matter intake and feed efficiency (Brink et al., 1990). Brown et al. (1975) found that cattle with severe liver abscesses had a decreased ADG by 12.7% when compared to healthy and mild liver abscess cattle. Liver abscesses in feedlot cattle effect animal performance, carcass yield and typically lead to liver condemnation resulting in an economic impact to the producer and packer.

Cattle treated at the feedlot, with lung lesions, lung condemnations and liver condemnations at slaughter, all present a decrease in carcass value for the producer. These indicators of illness affect the overall carcass value through evaluators of carcass weight, dressing percent and fat deposition. Presence of illness decreases the dressing percent, carcass weight and fat present on the carcass at slaughter. As a final result, cattle have a decreased quality grade and yield grade affecting the value allotted for the animal.

CHAPTER 2. ANIMAL HEALTH EFFECTS AND THE IMPACT ON CARCASS QUALITY

Introduction

Bovine Respiratory Diseases (BRD) is the leading cause of illness in cattle and represents 14.4% of illness that occurs in the feedlot (USDA APHIS, 2001). Cattle with BRD have been found to have both decreased feedlot production efficiency and less desirable carcass traits than cattle that never had BRD. Cattle with respiratory morbidity have decreased growth rates, and increased total days on feed (Gardner et al., 1999; Roeber et al., 2001; Thompson et al., 2006; Montgomery et al., 2009; Schneider et al., 2009). Cattle with BRD were also found to have decreased internal and external fat, carcass weights, as well as negative impacts on USDA Quality and Yield Grade (Gardner et al., 1999; Montgomery et al., 2009; Schneider et al., 2009). Lung lesions resulting from BRD are frequently found at slaughter, often in cattle that were never identified as clinically ill at the feedlot, and are an indicator of subclinical BRD. Gardner et al. (1999) noted that cattle with lung lesions present at slaughter had lower dressing percentage, and less marbling and twelfth rib fat thickness. Cattle without lung lesions at slaughter had 11% greater daily gains by and heaviest final live weights at harvest (Gardner et al, 1999).

Previous studies investigating the relationship between BRD and carcass traits have utilized cattle from commingled sources with other factors including preconditioning programs, breed type, infection of other diseases, and location. The questions posed for this study were: would a typical, commercial feedlot find a similar relationship among BRD and carcass traits similar to those found by other researchers, and would feedlot operators, insistent on profit, function similarly to university owned cattle?

The specific objectives of this study were to: 1) evaluate the relationship between cattle with and without identifiers of respiratory illness and carcass measurements of quality and cutability; and 2) evaluate the impact of BRD on cattle in the northern plains states.

Materials and Methods

Animals. Cattle (n = 2534) from Sinner Brothers and Bresnahan Feedlots in Casselton, ND that had receiving weights ranged from 250 to 346 kg and, ages were between 6 and 7 months of age at entry entered the feedlot between November, 2008 and June, 2009. Typical breed characteristics of the cattle include Hereford and Angus influenced black-white faced, red-white face, solid black and solid red. Upon arrival at the feedlot, all cattle were given a vaccination booster of a 7-way clostridial. Cow/calf producers were paid a premium for cattle that had a series of vaccinations prior to shipment to the feedlot. Cattle were fed a typical feedlot diet ad libitum that was 70% corn based diet with the remaining ingredients including haylage, beat pulp pellets, and a protein supplement.

Health Evaluation and Treatment. Cattle in pens were evaluated one to two times per day for symptoms of respiratory illness by trained feedlot personnel. Symptoms of BRD included droopy ears, cough and/or crusty nose and if cattle showing symptoms were present, the calf was removed from the pen for further evaluation. Body temperature was measured for any calf showing symptoms of BRD. If a calf had a body temperature above 39.4 °C, aggressive treatment was applied by administering Draxxin (tulathromycin injectible, Pfizer Animal Health; New York). Cattle typically would be returned to the home pen unless signs of pneumonia were present. If pneumonia was suspected, cattle were also treated with Banamine (flunixin meglumine, Intervet/Schering Plough Animal Health; New Jersey), and placed in the hospital pen for three days when re-evaluation would occur.

Carcass data. Cattle were harvested at an endpoint determined by the feedlot owner. Steers were delivered to Tyson Inc. (Dakota City, NE) for humane slaughter. Lung lesions were evaluated on 291 cattle by a common evaluator on 3 different slaughter dates. A rubric was developed at the beginning of the trial to ensure proper evaluation. Cattle were given a lung score of 0, 1, 2, or 3. Lung score of 0 was considered a healthy lung with no lesions present. Lung score of 1 indicated an active lesion or less than 10 % of the lung affected or trimmed off as an indicator of an abscess. Lung score of 2 indicated that 10 - 50% of the lung was missing, increased trauma to the lung tissue or a large portion left in the body cavity. Lung score of 3 was given if greater than 51% of the lung was affected or an entire lung was missing indicating severe pneumonia in which the lung adhered to the body wall during healing and was left within the body cavity at harvest. Lung condemnations (139 out of 1710 head evaluated) were also noted by evaluators and any condemnations that were the result of heart or trachea issues were disregarded when possible. Liver condemnations (365 out of 2298 head evaluated) were recorded after evaluation by a USDA inspector. Measurements of hot carcass weight were recorded from 2534 cattle, while USDA Quality Grade and Yield Grade were recorded from 2457 cattle. Ribeye area, marbling and 12th rib fat thickness were recorded from 294 cattle.

Statistical analysis. Carcass characteristics were analyzed considering each individual animal as an experimental unit. The data were analyzed using generalized least squares (PROC MIXED, SAS Institute, Cary, NC). The model included lung condemnation status, lung score, liver condemnation status and treatment as fixed main effects and harvest date as a random main effect. Animals with unknown status for the fixed effects were included as a separate category in order to include those observations in the estimate of the error term. All interactions were included in the initial model. The interactions that were clearly non-significant($P > 0.30$) were removed from the model. Tests of significance for mean comparisons were conducted utilizing the Tukey-Kramer method.

Results and Discussion

Mean carcass data of cattle within the study are presented in Table 2. The carcasses had a mean USDA Quality Grade of High to Average Choice with an average Yield Grade of 2.49. A summary is provided in Table 3 and includes percentages of cattle with the presence or absence of lung lesions, lung condemnations, and liver condemnations and if the cattle required treatment while in the feedlot. Fewer cattle were treated for BRD (3.40%) in this study when compared to previous studies conducted by Snowder et al. (2007), Garcia et al. (2010) and Schneider et al. (2009) whose incidence rates were 17%, 24% and 8 % respectively. The lower incidence of BRD in this study may have been due to the premium paid by the feedlot owner to producers for vaccination prior to entry at the feedlot. The percent of liver condemnations (15.90%) within the given cattle population falls within the incidence averages of most feedlots between 12 and 32% (Nagaraja and Chengappa, 1998).

Table 2. Carcass data means for entire population of beef cattle evaluated.

Item	N	Mean	SD	Minimum	Maximum
Quality Grade[1]	2457	2.31	0.52	1	4
Yield Grade	2457	2.49	0.71	1	5
Hot Carcass Weight, kg	2534	358.3	84	227	511
Ribeye Area, cm^2	279	85.16	1.29	61.3	111
Marbling[2]	279	427.63	84.2	289	794
12th Rib Fat Thickness, cm	279	1.12	0.13	.30	2.06

[1]Quality Grade = (QG) : 1 = USDA Prime; 2 = USDA Choice; 3 = USDA Select.
[2]MARB = Marbling Score numeric designation: 100 = traces; 200 = slight; 300 = small; 400 = modest; 500 = moderate.

Table 3. Summary of cattle with listed health conditions

Item	N	Percentage Population
Condemned lung	139	5.50%
Noncondemned lung	1571	62%
Not reported	824	32.50%
Lung Score	39	1.50%
Healthy Lung	252	10.00%
Not reported	2243	88.50%
Liver Condemned	365	15.90%
Liver Noncondemned	1933	84.10%
Treated	87	3.40%
Not treated	2447	96.60%

USDA Quality Grade was not affected by lung condemnation or lung score ($P >= 0.09$). Cattle with liver condemnations had a higher quality grade (2.3 ± 0.09; $P = 0.03$) than cattle with livers not condemned (2.4 ± 0.08). The presence of liver abscesses may indicate reduced growth due to decreased feed intake following a digestive upset. Depending upon when during cattle growing and finishing the digestive upset occurred could have impacted either protein or fat accretion. This observation has not been indicated previously and is an area of future study. Additionally, cattle treated for BRD had a decreased quality grade (Table 4) when compared to not treated cattle ($P = 0.001$).

Similar results were found by Schneider et al. (2009), who also determined the number of treatments given tended to indicate a further decrease in marbling score and the results were reflected in the quality grade. As the number of treatments given for BRD increased for an individual steer, the marbling score decreased and fewer cattle were entered into the Choice quality grade.

Table 4. USDA Quality Grade[1] from beef carcasses evaluated for lung condemnations, lung lesion score, liver condemnations and feedlot treatment.

Item	N	QG	SE	*P*-value
Condemned lung	139	2.3	0.2	0.09
Noncondemned lung	1571	2.2	0.1	
Not reported	824	2.6	0.1	
Lung Score	39	2.2	0.1	0.23
Healthy Lung	252	2.4	0.1	
Not reported	2243	2.5	0.1	
Liver Condemned	365	2.3	0.1	0.03
Liver Noncondemned	1933	2.4	0.1	
Treated	87	2.5	0.1	0.001
Not treated	2447	2.2	0.1	

[1]Quality Grade: 1 = Prime; 2 = Choice; 3 = Select.

USDA Yield Grade was unaffected by health condition and is represented in Table 5. The yield grade score was determined by the USDA graders upon evaluation of the external and internal fat and the hot carcass weight of the animal. These results are important for the packing plant as yield grade is the percent of closely trimmed, boneless retail cuts on a carcass thus providing and estimate of the amount of saleable product that is on each carcass. Health status did not affect yield grade, thusly packers don't have to consider the health status of the cattle throughout the time in the feedlot as percent yield was not affected. Currently, there is little information available about the impact these health measurements have on yield grade, thus the information from this study is valuable when producers are marketing their livestock to the packing plant.

Table 5. USDA Yield Grade from beef carcasses evaluated for lung condemnations, lung lesion score, liver condemnations and feedlot treatment.

Item	N	YG	SE	*P*-value
Condemned lung	288	2.56	0.23	0.21
Noncondemned lung	1933	2.43	0.17	
Not reported	236	2.05	0.18	
Lung Score	39	2.4	0.22	0.16
Healthy Lung	252	2.15	0.19	
Not reported	2243	2.48	0.08	
Liver Condemned	318	2.35	0.14	0.79
Liver Noncondemned	1903	2.34	0.13	
Treated	87	2.32	0.17	0.79
Not treated	2370	2.36	0.12	

Hot carcass weight was not significantly affected by health status, however, there was a tendency for cattle with lung condemnations and treatments to be affected (Table 6). Cattle with lungs condemned at slaughter had a tendency ($P = 0.08$) to have decreased hot carcass weight (326.8 ± 11.2 kg) when compared to their healthy counterparts (346.8 ± 3.7 kg). Limited data has been published pertaining to lung condemnations and may be a new area to consider. Lung condemnations relate to the overall quality of the lung tissue and may be simple data to collect. Treated cattle tended to have a decreased hot carcass weight (335.9 ± 9.7 kg) when compared to not treated cattle (349.5 ± 7.2 kg; $P = 0.07$). This data is similar to Montgomery et al. (2009) in which cattle treated for BRD had a decreased hot carcass weight compared to cattle untreated. There was an interaction for hot carcass weights for cattle free of liver and lung condemnations (354.5 ± 17.95 kg) to be different ($P = 0.04$) when compared to cattle affected with lung and liver condemnations (323.2± 25.5 kg). These differences may be an indicator of the effects of liver and lung condemnations on hot carcass weight. Cattle that were ill or had a disruption in the feeding period were not able to fully compensate by the end of the feeding period to meet the same hot carcass weights as the healthy counterparts in the study.

Table 6. Hot Carcass Weight (HCW) from beef carcasses evaluated for lung condemnations, lung lesion score, liver condemnations and feedlot treatment.

Item	N	HCW (kg)	SE	*P*-value
Condemned lung	139	326.5	24.62	0.08
Noncondemned lung	1574	346.1	17.9	
Not reported	824	353.6	20.85	
Lung Score	39	337.7	25.86	0.16
Healthy Lung	252	334.3	23.6	
Not reported	2243	354.2	10.77	
Liver Condemned	365	337.5	19.49	0.17
Liver Noncondemned	1933	346.7	17.64	
Treated	87	335.4	21.44	0.07
Not treated	2447	348.8	15.76	

Ribeye area (REA; Table 7) was unaffected for cattle with unhealthy ($P = 0.81$) or condemned lungs ($P = 0.99$); however, cattle with liver condemnations at slaughter had a decreased ribeye area (80.6 ± 1.55 cm^2; $P = 0.004$) compared to non-condemned livers (86.13 ± 0.97 cm^2). Powell (1966) found similar results in a trial evaluating effects of liver abscesses on production and carcass traits. It has been indicated that presence of liver abscesses interfere with normal physiological function through retardation of growth and fattening affecting longissimus muscle area and marbling (Powell, 1966). Liver abscess formation is the result of a digestive upset and commonly causes cattle to go off feed which results in fewer productive days for these cattle, which may ultimately affect the ribeye area because of retardation in growth.

Table 7. Ribeye area (REA) from beef carcasses evaluated for lung condemnations, lung lesion score and liver condemnations.

Item	n	REA (cm^2)	SE	*P*-value
Condemned lung	37	82.71	0.21	0.70
Noncondemned lung	156	83.03	0.18	
Not reported	2341	84.77	0.32	
Lung Score	34	83.29	0.23	0.81
Healthy Lung	252	83.68	0.13	
Liver Condemned	53	80.84	0.24	0.004
Liver Noncondemned	225	86.13	0.15	

Cattle with condemned lungs at slaughter were found to have increased marbling (459.5 ± 13.9; $P = 0.04$) when compared to non-condemned cattle (414.56 ± 11.8) as shown in Table 8. Lung condemnation at slaughter was also found to increase 12th rib back fat (1.35 ± 0.05 cm; $P = 0.04$). However, 12th rib backfat was not significantly affected by cattle with unhealthy lungs based on lung lesion score ($P = 0.12$) or liver condemnations at slaughter ($P = 0.66$; Table 9). The result, an increase in both internal and external fat as a result of lung condemnation, has not observed in previous studies and is unique our study. Previous studies found a decrease in marbling and 12th rib fat for cattle with symptoms of respiratory illness (Gardner et al., 1999; Montgomery et al., 2009). There are a variety of reasons why the increase in fat could have occurred including increased days on feed allowing more productive days than the healthy counterparts. We cannot verify this hypothesis as days on feed data was not available for analysis. Future studies will need to be conducted to verify if days on feed may be a factor with fat deposition increase.

Table 8. Marbling from beef carcasses evaluated for lung condemnations, lung lesion score and liver condemnations.

Item	N	MARB[1]	SE	*P*-value
Condemned lung	37	459.5[a]	13.94	0.02
Noncondemned lung	156	414.56[b]	11.81	
Not reported	2341	402.16[ab]	21.36	
Lung Score	34	417.91	15.29	0.36
Healthy Lung	252	432.91	8.79	
Liver Condemned	53	428.06	15.91	0.78
Liver Noncondemned	225	422.76	9.79	

[1]MARB = Marbling Score numeric designation: 100 = traces; 200 = slight; 300 = small; 400 = modest; 500 = moderate.
[a, b] Means with different superscripts within column were different (P < 0.05)

Table 9. Twelfth rib fat thickness (FAT) from beef carcasses evaluated for lung condemnations, lung lesion score and liver condemnations.

Item	N	FAT (cm)	SE	*P*-value
Condemned lung	37	1.35[a]	0.02	0.004
Noncondemned lung	156	1.14[b]	0.02	
Not reported	2341	1.02[b]	0.03	
Lung Score	34	1.22[a]	0.02	0.12
Healthy Lung	252	1.12[a]	0.01	
Liver Condemned	53	1.19[a]	0.02	0.66
Liver Noncondemned	225	1.14[a]	0.02	

Implications

This research provides further insight to the effects of BRD on carcass quality with similarities and discrepancy's when considering previous research along with new insight to consider. Only 3.4% of the cattle in the study were treated for BRD which was a low incidence rate for BRD compared to previous studies which estimated 8-14% illness. This low incidence of BRD may indicate that cattle of the northern plains are less susceptible to BRD or that cattle in this research were better prepared for the feedlot at entry. Cow/calf producers were paid a premium for vaccination administration prior to entry into the given feedlot and may have better prepared the immune system for exposure to foreign bacteria. Overall, lung condemnation affected carcass characteristics through a decrease in hot carcass weight. Our study is unique through the evaluation of lung condemnations at slaughter as a way to address the health of the entire lung and not just parameters known to be specific to BRD. This measurement is less subjective by the evaluator and can be taken by any individual without prior training. Results differing from previous studies was that marbling and 12th rib fat thickness were increased for cattle with condemned lungs, one indicator of respiratory illness. Further research needs to consider whether this is due to an increase in days on feed, or if this is particular to the given breed influences utilized on this feedlot. Administration of antibiotics for treatment of BRD did not affect cattle as significantly as was found in other studies; however, quality grade was reduced which was similar to other research. With the low incidence rate of BRD within the given study, the number of cattle treated in this data set may not be adequate to accurately measure the effects of treatment on these traits. Liver condemnation was found to decrease ribeye area in this study and concurs with a study conducted by Powell (1966) that found retardation in growth due to liver abscesses. Liver condemnation also decreased USDA Quality Grade and may negatively impact the value of the cattle for producers. Further research needs to be conducted including a greater incidence rate of BRD within the population and include the health parameters utilized in the given study to associate the affects to production and carcass characteristics of cattle.

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APPENDIX A

Hot Carcass Weight sorted by slaughter date.

Date	N	Mean	SEM	Min	Max
4/28/2009	41	371.7	11.00	315.9	440.0
4/30/2009	49	329.4	8.47	283.6	387.7
5/7/2009	41	364.7	11.00	320.5	284.1
5/8/2009	43	346.9	11.50	269.1	444.5
5/11/2009	40	387.1	11.00	282.7	431.4
5/12/2009	84	379.1	7.72	303.2	459.5
5/14/2009	67	336.8	8.02	266.4	424.1
5/15/2009	47	365.2	7.87	301.4	428.6
5/19/2009	88	364.8	7.87	290.0	439.1
5/20/2009	43	344.5	12.20	269.1	417.3
5/21/2009	50	316.3	9.04	227.7	403.6
5/22/2009	22	345.0	16.20	281.4	405.5
5/27/2009	47	359.8	8.01	307.7	421.4
5/29/2009	91	353.6	10.20	260.5	511.8
6/2/2009	46	365.3	8.94	300.0	411.4
6/3/2009	148	351.4	7.24	251.4	447.3
6/10/2009	134	352.1	6.84	251.8	436.4
6/11/2009	84	376.1	10.30	295.0	484.1
6/17/2009	22	359.6	13.40	286.8	397.3
6/18/2009	42	360.9	11.60	280.0	436.8
6/19/2009	95	332.1	7.54	266.4	407.7
6/23/2009	137	345.7	5.61	262.7	420.9
6/24/2009	81	385.3	8.14	260.0	460.0
6/25/2009	84	356.3	8.00	256.4	442.7
6/26/2009	106	346.2	7.92	256.8	435.5
7/8/2009	45	350.2	13.10	282.3	442.7
7/9/2009	59	367.4	11.60	242.3	455.0
7/14/2009	43	373.7	9.83	292.7	433.6
7/15/2009	42	355.1	13.60	283.6	439.5
7/22/2009	84	366.3	8.63	272.7	460.0
7/23/2009	130	355.0	6.29	281.4	434.5
7/29/2009	86	357.4	8.78	254.1	440.5
7/30/2009	88	347.4	7.25	295.9	429.1
10/7/2009	77	367.4	7.17	298.6	433.6
12/8/2009	72	407.2	7.37	326.8	485.0
12/16/2009	76	405.7	5.98	355.5	464.5

APPENDIX B

Quality Grades of cattle sorted by slaughter date

QG Breakdown by Slaughter Date					
	Prime	**Choice**	**Select**	**No Roll**	**Grand Total**
4/28/2009	1	32	8		41
4/30/2009		40	8	1	49
5/7/2009	2	30	7	2	41
5/8/2009	2	41			43
5/11/2009		25	15		40
5/12/2009	4	64	16		84
5/14/2009		42	25		67
5/15/2009		36	11		47
5/19/2009		62	25	1	88
5/20/2009		26	17		43
5/21/2009	1	39	10		50
5/22/2009	1	17	4		22
5/27/2009		30	15		45
5/29/2009	2	66	21	2	91
6/2/2009	2	26	17	1	46
6/3/2009		95	43	10	148
6/10/2009	1	81	51		133
6/11/2009		54	26	4	84
6/17/2009		19	3		22
6/18/2009		37	5		42
6/19/2009		72	22	1	95
6/23/2009		83	51	3	137
6/24/2009	2	40	39		81
6/25/2009	2	67	13	2	84
6/26/2009	1	84	19	2	106
7/8/2009		20	24	1	45
7/9/2009	2	42	15		59
7/14/2009		26	16		42
7/15/2009		20	22		42
7/22/2009	1	42	37	4	84
7/23/2009	1	91	38		130
7/29/2009	1	46	35	4	86
7/30/2009	1	43	42	2	88
10/7/2009	3	59	10		72
12/8/2009	1	66	8		75
12/16/2009	**31**	**1663**	**718**	**40**	**2452**