AN ABSTRACT OF THE THESIS OF

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Title: Growth and Carcass Merit of Purebred Jersey Steer Calves Finished on Grain-based Diets at Two Different Energy Levels.

Abstract approved:

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ABSTRACT: Purebred Jersey steers are often overlooked for beef production due to the perceived poor growth and production. Currently dairy persons marketing their steer offspring are receiving minimal compensation due to lack of demand by beef feeders and a saturated veal market. Twenty purebred Jersey steers were used to evaluate lifetime growth and carcass development while finished on different caloric-density diets. Daily rations were distributed by pen during the growing phase and individually during the finishing phase. Finishing diets were formulated for either 70% concentrate (F70) or 85% concentrate (F85) to determine the influence of caloric density on body composition. Growth, intake, and carcass data were analyzed as a randomized complete block design with initial BW groupings (LIGHT and HEAVY) as the blocking factor. Data from the growing phase (169 d) were analyzed as LIGHT versus HEAVY, whereas data from the finishing phase were analyzed as LIGHT versus HEAVY and F70 verses F85. The HEAVY steers were 8% heavier (P <0.05) at harvest than LIGHT steers and tended (P<0.10) to consume more DMI although they were not different (P>0.10) in G:F. The F85 steers had greater (P<0.05) ADG (0.91 versus 0.82 kg/d) and greater (P<0.05) G:F

(0.12 versus 0.11 kg/kg) which allowed them to be 5.6% heavier at harvest versus F70 steers. The HEAVY steers had 12.5% heavier ($P<0.05$) HCW with a 13% advantage ($P<0.05$) in REA over LIGHT steers. Steers consuming the F85 finishing diet had 6% greater ($P<0.05$) HCW and 12% advantage in REA over F70 steers. Although all steers reached choice grade, F85 steers tended ($P<0.10$) to have greater marbling over F70 steers (640 versus 590, respectively). At harvest, 9-10-11 rib sections were removed from the left side of each carcass to undergo meat quality testing. Meat samples from the F85 steers tended ($P<0.10$) to be more flavorful and juicy versus the F70 steers. Meat samples from the HEAVY steers tended ($P<0.10$) to be more flavorful, but had greater ($P<0.05$) off-flavor scores versus the LIGHT meat samples. Subcutaneous fat samples from the F70 steers had greater ($P<0.05$) concentrations of c-9, t-11 CLA than the F85 steers. Steric acid was found in the greatest concentrations in KPH and omental fats (21.3 to 23.4% total fatty acid), while being least concentrated in the subcutaneous fat (7.9 to 9.2% total fatty acid). Jersey steers have the ability to produce highly marbled carcasses with potential health benefits and acceptable meat attributes; however, the carcass quality must be valued against low growth efficiency.

Key Words: Carcass, Growth, Jersey, Meat Quality

Growth and Carcass Merit of Purebred Jersey Steer Calves Finished on Grain-based Diets at Two Different Energy Levels

by
Garrett L. Tschida

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Garrett L. Tschida, Author

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CONTRIBUTION OF AUTHORS

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CHAPTER 1

LITERATURE REVIEW

INTRODUCTION

As the United States and world population continues to increase, the acreage available to produce food and fiber for the world continues to decrease. The world population is projected to exceed 9 billion by 2050 (FAO, 2009). The Food and Agricultural Organization (FAO, 2009) projects that the agricultural industry will need to increase their current production by nearly 70% in order to provide enough food for the estimated population with the majority residing in urban settings. This is of concern because humans get their vital nutrients needed to sustain life (Givens et al., 2006) by either tillage of the soil or having animals convert plants from un-tillable soil into vital nutrients. The meat industry itself will need to provide nearly 200 million tons of food with an additional 1 billon tons of cereal grains needed to help meet the amplified demands from population growth (FAO, 2009). Furthermore, consumers in the United States want production agriculture to transition to more sustainable and ethically responsible production systems. To better understand sustainability, one must examine all potential impact areas in order to have a sustainable system. The National Cattleman's Beef Association (**NCBA**) in conjunction with BASF North America and the United States Department of Agriculture- Agriculture Research Service teamed up to do a life cycle assessment of the efficiencies of beef production while determining baselines that can be used to monitor future growth as the beef industry moves to a more sustainable culture. Sustainability, as determined by the beef sustainability project, can be defined as "the process of meeting beef demand by balancing environmental responsibility, economic opportunity and social diligence throughout the supply chain" (NCBA, 2013). Additionally, while conveying to readers about management systems and the importance of integrating and sustaining resources, Field and Taylor (2003) stated "Making holistic and integrative management decisions that will sustain or improve all the resources (e.g., land, financial, cattle, and people) while increasing or sustaining high profits is the goal." Field and Taylor's opinions of sustainability can be easily aligned with NCBA's opinion that sustainability can be grouped into three main areas: social (ethical considerations), environmental (maintaining and improving land), and economical (in order to provide a readily available, cost tolerable, safe product for consumers). As beef producers continue to progress and make a cultural change with advancements that are more efficient and sustainable, one must keep in mind that "sustainability is a journey of continuous improvement rather than a destination" as stated by NCBA (2013). In order to reach these goals, the beef industry needs to determine how they can efficiently meet the increased product demands that are needed to provide food and fiber, from sustainable practices, on a national and global scale, Marshall (1994) stated "To compete with other sources of food protein, the beef industry must produce specified meat products in a predictable and cost efficient manner."

In order to achieve cost efficient and predictable products, the beef cattle industry needs to weigh all potential options to increase production while utilizing the resources already available to meet these demands imposed by consumers and the government. The beef industry currently employs several techniques that are used to make animals more efficient while increasing overall output of product. One way to increase production (yield of beef) is the utilization of genetics, or simply: heterosis. Heterosis (expressed as the crossbred progeny) is a performance advantage that is gained by combining traits that are superior in one animal and combining those traits with another animal's superior traits (Field and Taylor, 2003). Heterosis is founded on the principles that not one breed excels in all economically important traits. Improvement in the animal can be realized through moderate improvements in growth and moderate to high improvements with regards to disease resistance (improved immune system and potentially less antibiotic use) (Field and Taylor, 2003). However, not all things can be improved through heterosis, as there will be minimal improvement to carcass composition (Marshall, 1994).

Metabolic modifiers. An additional resource that is utilized to increase beef production is the use of anabolic implants. Duckett and Andrae (2001) reported that there were 26 anabolic implants approved for use in beef cattle production with the ability for use in suckling calves, stockers, and feedlots. Producers utilizing anabolic implants can achieve improvements of gains by 6% in the suckling phase, 15% in the stocker phase and 20% in the feedlot phase (Duckett and Andrae, 2001). The increase in gains equates to 8 kg for suckling phase with an increase of $16.32 per animal, stocker phase calves should see an increase of 15 kg and an improvement of $25.20, while the feedlot phase calves should see a 34 kg increase in body weight (**BW)** with $51.34 being realized per animal (Duckett and Andrae, 2001). Sawyer et al. (2003) reported a 9% increase in finish weight utilizing anabolic implants and had a 17% increase in average daily gain (**ADG**), although the steers did consume an additional 1.04 kg of dry matter (**DM**), they still tended to be more efficient (5%) than steers not receiving an implant. Additionally, cattle that received an implant had a 9.5% increase in hot carcass weight

(**HCW**) and 8.5% increase in longissimus muscle (**LM**) area. Steers that received an implant sacrificed intramuscular fat as evident by a lower marbling score (4.57 vs. 5.20; 4 = small, 5 = modest) although they still fell within the choice quality grade (Sawyer, et al., 2003).

Another resource available is synthetic β-adrenergic agonists (**β-AA**). The use of synthetic β-adrenergic agonists has started to become more common in the beef industry. Synthetic β-AA increases the rate and efficiency of protein deposition within the lean tissues by altering the growth-modifying agents that are present (Bell et al., 1998). Synthetic β-AA affect multiple faucets of the animal's available nutrients which leads to the increased production of lean tissue (muscle) and decreases the amount of fat deposition that occurs (Bell et al., 1998). Vasconcelos et al. (2008) conducted a study in which four levels (0, 20, 30, of 40d pre harvest with a 3 d withdrawal) of synthetic β-AA were fed to cattle. Cattle live BW was not affected between cattle receiving no synthetic β-AA and those that did receive a synthetic β-AA supplementation for 20, 30, or 40d pre harvest (Vasconcelos et al., 2008). However, as dosage days increased, dry matter intake (**DMI**) decreased with gain-to-feed (**G:F**) efficiencies increasing at a linear rate (Vasconcelos et al., 2008). Upon harvest, all cattle that received the synthetic β-AA had greater HCW, and greater dressing percentages, less backfat at the 12^{th} rib, an increase in LM area, less kidney, pelvic, heart fat (**KPH**), and ultimately a lower USDA yield grade (Vasconcelos et al., 2008). Vasconcelos et al. (2008) reported an increase of 4 to 4.5% in HCW when cattle were fed the synthetic β-AA. Additionally, LM area increased by 9 to 10% on cattle consuming the supplement with the synthetic β-AA included into the ration; however, cattle that were fed only 30 d realized the largest increase in LM area.

Fat thickness at the 12^{th} rib was reduced by 9 to 14% while KPH percentage decreased by 3 to 6%. Therefore, it was no surprise that yield grade saw a reduction of 14 to 19% (Vasconcelos et al., 2008).

Non-beef cattle breeds. Another possible avenue to increase beef production is through encompassing of non-beef cattle (i.e. dairy breeds) into the beef production supply. Currently, the two prominent breeds of dairy genetics in the United States are Holstein (84.70% of herd numbers) and Jersey (6.21% of herd numbers) (USDA, 2013a). The population being skewed to Holstein is not surprising as dairy persons were paid based off of total fluid milk sales. From the inception of the Federal Milk Marketing Order system, which was authorized under the Agricultural Marketing Act of 1937, dairy producers were paid off of a volume milk fat differential (Elbehri et al., 1994). This pricing scheme determined a base price for fluid milk and had the requirement that it must test at least 3.5% milk fat at 45.35 kg of fluid milk to receive the base price with a premium or discount for every 0.1% change in milk fat to the base price at which the producer was paid (Elbehri et al., 1994). Holsteins have the advantage in overall fluid milk production, out producing their Jersey counterparts by 28% (10,790 vs 7,724 kg of milk per cow, respectively) (USDA, 2013b). Elbehri et al. (1994) described that as dairy products change with consumer preference for more protein-based products, creameries are reevaluating the methods dairy producers are being paid which has developed into a pricing scheme based on individual components of their fluid milk. Jersey has a slight advantage in individual components that comprise the fluid milk. In 2012, Jersey milk was comprised of 4.77% fat and 3.64% protein whereas Holstein milk was 3.66% and 3.08%, respectively (USDA, 2013b). Although the percentage of fat and protein are not greatly different, it has allowed Jersey cattle to be more valued for the quality of the product, while the component pricing has little impact on Holstein operations (Elbehri et al., 1994). Over the last ten years, Jersey numbers have increased 41% while the Holstein breed has seen a 6% decrease in cow numbers (USDA, 2013a; 2013b). Additionally, crossbred milk cows have increased 66% over the same time frame (USDA, 2013a; 2013b). Weigel and Barlass (2003) suggest that there are three main reasons for increased crossbreeding: 1) changes in milk pricing (from fluid, fat corrected to component pricing); 2) production benefits such as female fertility, calving ease, and health; and 3) reduction of inbreeding.

Currently, the beef industry is feeding limited numbers of Jersey steers due to their expected poor growth traits. This could be explained by the feedlot industry grouping by class and miss-understanding the Jersey's growth and development rates. Today, the feeding industry combines them with their dairy cohorts (i.e. Holsteins) which are larger framed and have different growth rates for muscle and fat accretion. However, more research needs to be completed on the growth patterns and various feeding protocols that can be used to assist in feeding the smaller framed Jersey animals more accurately. Once completed, education needs to take place for feedlot personnel as Jersey beef could be a viable option to assist in meeting the demands to feed the world continue to increase.

DAIRY BREEDING MANAGEMENT

Advancements in technologies have allowed agricultural products to meet the increased demands of providing food and fiber. One such technology, implemented in the early 1900s, is artificial insemination (Field and Taylor, 2003). Artificial insemination (**AI**) has allowed dairy producers to meet the increased demands of milk products by accessing the top sires that have improved fluid milk production as well as milk components (protein, fat, etc.). Advancement of AI has created an unintended consequence by creating a weak and highly saturated market for male progeny of dairy genetics.

Today, many dairy producers are at the forefront of technological advancements and its incorporation into production systems. The ability to control progeny sex selection at conception has been highly sought after for many centuries (Garner and Seidel, 2008). It was an advancement in 1981 that determined that DNA content could be measured (Garner and Seidel, 2008) and that the bovine Y-chromosome bearing sperm contains 3.8% less DNA than the X-chromosome bearing sperm (Weigel, 2004; De Vries et al., 2008). With that knowledge, sperm can then be treated with a fluorescent dye and sorted using flow cytometery (Weigel, 2004, De Vries et al., 2008) with high accuracy (85 to 95%) (De Vries, 2008). Sexed semen has continued to increase since 2006 although more predominantly with heifers opposed to mature cows (Norman et al., 2010). A survey conducted by Norman et al. (2010) found that 37% of active Holstein AI sires, had marketed sexed semen. However, Weigel (2004) noted that the use of this technology has been impaired by two key factors: sorting speed and conception rates. Conception rates in trials ranged from 35 to 40% (Weigel, 2004; Norman, 2010) for sexed semen compared to conventional (unsexed) that ranged from 55 to 60% (Weigel, 2004; Norman et al., 2010). Once conception is confirmed, producers should expect the progeny to be the desired sex 90% of the time (De Vries et al., 2008). Utilizing sexed semen can prove to be a viable option. Dairy persons utilizing this technology are looking to provide them with an end product to create more revenue in the future (replacement milking females). The use of AI and sexed semen has allowed multiple management scenarios for the dairy person to explore. One such management scheme would be to breed the top animals in their herd (either a percentage or total number) with female sexed semen to increase the probability of having a female to go into the milking herd. That would allow the use of conventional AI on the remainder of the herd utilizing a terminal cross (Angus) that would potentially allow their offspring to be more efficient and make the transition into the conventional feeding industry and beef market more effectively. Doing this management practice helps reduce expenses, while increasing focus on replacement females and help eliminate the marketing issues that dairy producers are facing today for male progeny.

With the current market, Jersey producers attempting to market their male progeny are in a "no-win" situation. Not only are they contending with the expected poor growth performances and lost revenues, but ethical and welfare considerations arising from the two prominent avenues for male offspring: 1) veal production, or 2) euthanasia. Veal production is being scrutinized not only by dairypersons, but also by animal rights/ welfare groups and legislative bodies. In 2011, the United States harvested 838,825 hd for veal production under federal inspection (USDA, 2012). This number is 24,796 hd less than 2010 (USDA, 2012). Although calves are still marketed for veal production, it is not necessarily a viable marketing option for dairy producers. Not only does the veal industry have new restraints on established production practices, it faces logistical issues as well. Currently there are minimal farms producing veal, especially in the western

United States, which would create an even more saturated market that would be cost prohibited.

The second avenue for male Jersey offspring is, euthanasia, which is a greater social and ethical dilemma. Euthanasia of bull calves is more frequent in Jersey herds due to their smaller stature, and poor growth and production traits (Smith et al., 1976); especially compared to beef-oriented breeds. Due to their large stature and overall weight advantage, Holstein calves can remain profitable under certain beef production circumstances and therefore, euthanasia is less prominent. A Denmark survey of organic beef producers (Nielsen and Thamsborg, 2002) found that 59% of Jersey bull calves were euthanized after birth due to difficulty in selling to conventional farmers; whereas, only 0.5% of Holstein bull calves were euthanized after birth. Nielsen and Thamsborg (2002) also stated that some may consider and view this as a serious ethical concern; especially, for organic farming which is supposed to provide a holistic approach to production in Denmark. There currently has not been a study conducted in the United States among dairy producers to determine the rate at which euthanasia after birth is occurring; however, one could conclude that it is at a similar rate to Denmark as producers feel it is more ethical and economical to euthanize calves at birth rather than raising for veal.

The Jersey and Holstein breeds are distinctly different animals, which affect their acceptability in the beef industry. Holsteins have proven themselves and are accepted in the beef industry due to their overall growth, frame, and carcass consistency allowing them to have greater yields of beef upon harvest. A California study looked at feeding Holsteins and reported ADG of 1.37 kg/d, DMI of 9.87 kg/d and G:F of 0.141 kg/kg (Beckett et al., 2009). Beckett et al. (2009) also conducted a similar study in

Arizona and reported Holstein steers gaining 1.33 kg/ d, with DMI of 9.14 kg/d and a G:F of 0.146 kg/kg. Apple et al. (1991) conducted a Holstein steer study in Kansas and reported ADG of 1.22 kg/ d, a DMI of 8.38 kg/d and a feed-to-gain of 6.88. Carcass traits for the three studies had a range of HCW of 289.5 to 394.4 kg, with a 60% or greater dressing percent and ribeye area (REA) ranging from 66.44 to 81.2 cm^2 (Apple et al., 1991 and Beckett et al., 2009).

Unfortunately, early research conducted on crossbred Jersey sired cattle has resulted in Jersey steers to be overlooked for cattle feeding due to their expected poor growth (Alberti et al., 2008; Smith et al., 1976) and decreased return on investment when fed out and marketed as commodity beef. Determining the value of Jersey beef under current production settings has proved to be a challenge. In order to stimulate and improve the current market for purebred Jersey steers; additional research, conducted with current genetics and management techniques, is needed in order to provide dairypersons with another sustainable, ethically responsible marketing avenue and encourage beef producers to accept Jersey bull calves as alternatives.

GUIDELINES FOR COMMERCIAL BEEF PRODUCTION

Growth and Development

Under current production management schemes, beef cattle are usually profitable when gain is maximized and inputs reduced. Feed is the most expensive input cost, which make days on feed (**DOF**) an important index of cattle profitability. Days on feed are largely dependent upon both the genetic makeup and age of the cattle when they enter the feed yard. Cattle that enter the feed yard as calf feds are going to require more time on feed than calves that have been allowed to grow through extended grazing systems and enter the feed yard as yearlings. Cattle should be on feed at least 100 d for yearling cattle and 180 d for calf feds (BIF, 2010) in order to achieve a profitable carcass once harvested. One must keep in mind that each pen and group of cattle is different depending on frame size, genetic base, and previous nutritional management which all influence DOF. A summary of 9,683 pens of steers on feed in the western United States determined that there was a range of 130 to 197 DOF; with beginning weights of 285 to 384 kg and final weights of 542 to 618 kg (Zinn et al., 2008). Zinn et al. (2008) reported ADG values of 1.34 to 1.75 kg per day were achieved by cattle being fed diets of NE_g values ranging from 1.42 to 1.52 Mcal/kg; while the cattle consumed 7.77 to 11.13 kg of DM per day. Cattle in the survey had G:F efficiencies ranging from 0.16 to 0.17 kg/kg. A 168 d post-weaning gain study (Gilbert et al., 1993) that encompassed Angus and Hereford breeds fed at two different levels of energy, found that steers consuming the high energy diet (20% alfalfa hay) had the advantage in all growth measures when they were analyzed at the end of the post weaning gain test over the low energy diet (100% alfalfa hay). Additionally, the high energy diet cattle had 36% more growth (1.167 kg/ d) with a greater relative growth rate with 0.426%/ d while the low energy diet cattle had an ADG of 0.748 kg/ d and a relative growth rate of 0.305%/ d (Gilbert et al., 1993). Feed efficiency is an important consideration as it affects the overall efficiency of beef cattle production (Smith et al., 1976); and overall profitability due to the direct impact on cost of production and net return (BIF, 2010).

Carcass Merit

In order to be profitable, fed cattle must meet minimum requirements for quality (grade) and yield aspects (carcass weight and fat thickness) when marketed on a grid basis. Grid pricing are benchmarks that are set forth by packers, and designed to promote uniform beef production. The grid pricing concept is a complex system where cattle are assessed premiums and discounts for quality grade (prime, choice, select, standard), yield grade (determination of cutability), HCW, and various defects that the carcass may exhibit (dairy, dark cutter, bullock, etc.) (Field and Taylor, 2003). Grid benchmarks become evident when viewing the *Weekly National Carlot Meat Report* that is published on a weekly basis by USDA Agricultural Marketing Service. The weekly pricing report is based off of the prior week's harvest and outlines the premiums and discounts that packers assigned cattle when processed (Field and Taylor, 2003). For cattle to receive the grid base price with no premiums or discounts received, cattle must reach the choice grade, have a yield grade of 2.5 to 3.0, and a HCW of 272 to 408 kg. Therefore, in order to reach those carcass weights, cattle must have live weights of 432 to 648 kg using a 63% dressing percentage. To help determine the benchmarks needed for beef cattle to be profitable, one can also look to the preliminary yield grade (**PYG**) formula to help determine respective points for reference. Beef carcasses reaching the benchmark of 272 kg (HCW), and using the PYG, cattle must yield a REA of 71cm^2 while having a backfat of 1.02cm or less in order to achieve yield grades of 3.0 or less (BIF, 2010). These guidelines can be achieved; however, it is dependent upon several factors including, but not limited to, genetics, age, ration composition and consequently the DOF.

The National Beef Quality Audit (**NBQA**) takes place every four to five years and provides a valuable snap shot of the fed beef cattle industry. Moore et al. (2012) found in the 2011 NBQA that on average HCW weighed 374.0 kg with a range from 140.4 to 545.7 kg. In a survey of western United States feedlots, dressing percentages averaged 63.3% for steers with a range of 61.4 to 64.8% (Zinn et al., 2008), which is in agreement with the MARC data (Koch et al., 1976). Therefore, using the 63.3% dressing percentage (Zinn et al., 2008) and the range of HCW (Moore et al., 2012) beef cattle had live weights of 221.8 to 862.1 kg, averaging 590.8 kg. Moore et al. (2012) reported that 75% of cattle fell within the carcass weight benchmark of 272 to 408 kg. Hot carcass weights have increased 7.8% in the last twenty years (1991 to 2011 NBQA) (Lorenzen et al., 1993; Moore et al., 2012).

The NBQA has reported an increase (6.1%) in overall LM area since 1991 (83.4 to 88.8 cm^2 in 2011) while reducing the amount of backfat on carcasses from 1.5 to 1.3 cm (Lorenzen et al., 1993; Moore et al., 2012). Cattle within the NBQA also returned an average USDA yield grade 2.9, which has decreased 10% over the last twenty years (Lorenzen et al., 1993; Moore et al., 2012). A lower yield grade is also desirable as it indicates there is more saleable product and will require less trim. In the data reported by Zinn et al. (2008), 48% of the cattle graded choice and had yield grade scores ranging from 1.90 to 2.86. Marshall (1994) noted that the quality of beef is primarily determined by intramuscular fat, and marbling accounts for 90% of the variation in carcass grades (Field and Taylor, 2003). The NBQA has seen a 3.6% increase in marbling score (424, 1991; 440, 2011; 300 = slight^{00}, 500 = modest^{00}) and a 1% increase in USDA quality grade (686, 1991; 693, 2012; 600 = select^{00}) (Lorenzen et al., 1993; Moore et al., 2012).

Gilbert et al. (1993) reported that cattle consuming a high energy diet (20% alfalfa) achieved marbling scores of 7.3 (7 = small, choice) when feed the same diet after weaning and 7.6 (7 = small, choice) on cattle that were fed a moderate energy diet (100% alalfa) for 168 d and then finished out on the high energy diet (20% alfalfa). As cattle sources are identified for positive gain, development characteristics and carcass quality, cattle buyers and feeders are likely to pay a premium for feeder cattle. However, the producer must establish a relationship with cattle buyers and feeders in order to receive these premiums.

JERSEY BEEF PRODUCTION

Currently there are minimal studies looking at purebred Jersey steers for beef production. Lehmkuhler and Ramos (2008) initial study found that altering the metabolizable energy in the diet did not alter ADG or DMI. In their follow up study, Lehmkuhler and Ramos (2008) fed purebred Jersey steers two different feeding protocols: 1) a high energy diet through the duration or 2) a phase feeding protocol. The authors found that there were no difference between the two feeding protocols and saw ADG of 1.17 to 1.13 kg/d, DMI of 6.0 to 6.2 kg/d and G:F of 0.19; however, those Jersey steers on the high energy diet throughout the duration of the trial required 10 fewer days compared to the phase fed steers (Lehmkuhler and Ramos, 2008). Additional research on the meat characteristics of purebred Jersey steers has been published (Arnett et al., 2012) although no growth performance from the study was reported.

There have been a few studies published with data that has utilized crossbred Jerseys with the majority of research taking place in the late 1970’s and early 1980’s

(Alberti et al., 2008; Gaskins et al., 1982; Koch et al., 1976; Smith et al., 1976). Studies were designed using multiple sires of different breeds of cattle bred to a genetically similar female herd, either Angus or Hereford genetics, to determine their potential impacts to the bovine industry (Koch et al., 1976; Smith et al., 1976). The most in-depth research has been that conducted at the United States Department of Agriculture Meat Animal Research Center (MARC) which investigated growth characteristics (gains and feed conversions), but also evaluated carcass traits which influence profitability and production efficiency. These production studies gave producers insight into the biological attributes that encompass the individual breeds, allowing them to increase production efficiency and meet the demands of the changing market (Koch et al., 1976). However, one must keep in mind that the crossbred studies were impacted due to heterosis and doesn't allow an accurate portrail of the purebred Jersey steer.

Growth and Development

Purebred Jersey Data. Lehmkuhler and Ramos (2008) reported Jersey steers consuming two different roughage levels during a phase feeding program had DMI of 4.6 kg/d, ADG of 1.01 kg/d and G:F of 0.22 kg of BW from 0 to 90 d (Period 1). During period 2 (91 to 173 d) the purebred Jersey steers consumed 5.6 kg DM daily while gaining 0.93 kg/d, and achieving a G:F of 0.17 kg of BW / kg of DMI. During the finishing phase (174 to harvest, 250 d), steers consumed 7.2 kg DM daily, gained 1.27 kg/d with a G:F of 0.18 kg BW daily for every kg of DMI. Steers at the completion of the trial achieved weights of 382 kg.

As a follow up study to their phase feeding study, Lehmkuhler and Ramos (2008) completed a study that encompassed two finishing techniques: 1) constant roughage level (10%) or 2) phase feeding with decreasing roughage (30%, 20%, 10% roughage) inclusion in the diet. Throughout period 1 (0 to 84 d) phase feeding steers gained 1.04 kg daily while consuming 4.3 kg of DM daily which was 2.7% of steers BW. This allowed steers to add 0.24 kg of BW daily for every kg of DM consumed while on the phase feeding protocol. Period 2 (85 to 168 d) phase feeding saw the Jersey steers gaining 1.11 kg per day while consuming 5.2 kg/ d. This equates to be 2.1% of BW for steers fed according to the phase feeding protocol. Additionally, phase fed steers in period 2 recorded gain efficiencies of 0.21 kg of gain per kg of DMI. Jersey steers, following the phase feeding protocol, achieved a finishing (169 to harvest) performance of 1.13 kg gain per day with a DM consumption of 6.0 kg/d (2.0% of BW) and gain efficiency of 0.16 kg of BW per kg of DMI. Phase feeding purebred Jersey steers had overall daily gains of 1.13 kg daily, while consuming 2.0% of their BW and obtaining G:F of 0.19. Conversely, high energy steers consumed 2.8% of BW with a daily gain of 1.26 kg per day, a DMI of 4.7 kg, and gain efficiency of 0.27 during period 1. Throughout period 2, steers recorded 1.06 kg per day in daily gain, consumed 5.7 kg of DM daily (2.1% of BW) and had a gain efficiency of 0.19. Steers through the finishing phase period had an average daily gain of 1.18 kg, consumed 7.2 kg / day of DM (1.8% of BW), and had a gain efficiency of 0.16. Steers on the high energy finishing protocol had a final BW of 487 kg, an overall average daily gain of 1.17 kg, consumed 6.2 kg of DM (2.1% of BW), and gain efficiency of 0.19. However, purebred Jersey steers consuming the constant level of forage were able to reach their final weights 10 d faster (317 vs. 327 d) than their phase finished countrerparts.

Jersey Crossbred Data. Smith et al. (1976) summarized the postweaning growth and efficiency data from MARC in 1970s. From trial commencement, Jersey crosses (**Jx**) were the lightest in terms of BW (221 kg) and remained the lightest as DOF increased compared to other breeds represented in the trials. As a result, Jx weighed the least (408 kg) at 405 days of age. Smith et al. (1976) reported ADG values ranging from 1.04 to 1.25 kg/day for Jx cattle. Relative growth rate (RGR) [RGR = $(\ln W_2 – \ln W_1)/(t_2 – t_1)$] is a percentage of growth by the animal per day and is an important factor as cattle who gain faster tend to be more efficient than those cattle that are slower gaining (Smith et al., 1976). Relative growth rates of Jx grew (0.342%) the least of all the counterparts (average RGR) in the trial. Due to their light weight and low RGR, Jx cattle were the slowest growing. When efficiency is reported at a constant weight, Jx were the least efficient between the 240 kg to 470 kg growth stage, requiring 24.54 Mcal of metabolizable energy per kg of gain (Smith et al., 1976). Additionally, Gaskins et al. (1982) reported data of Jersey X Angus bulls characterizing gain during a post-weaning test feeding at three different levels in relation to the sire's maintenance requirements. Average daily gains of 0.15, 0.55, and 0.96 kg/ day were reported when fed at 1.2, 1.7, and 2.2 times the estimated maintenance requirements of the sires during period 1. Period 2 ADG were 0.13, 0.76, 1.22 kg/ day at 1.2, 1.7, and 2.2 times the estimated requirements. During the final period of the post-weaning gain test, where bulls were fed ad-libitum full feed, ranged from 1.45 to 2.26 kg/ day. The bulls also gain efficiencies of 0.16 to 0.20 kg/kg.

Carcass Merit

Purebred Jersey Data. Arnett et al. (2012) found that Jersey steers consuming a high forage diet (24% DM basis) during growth and finishing phases produced steers that had live BW of 466 kg and HCW of 278 kg. Therefore, the purebred Jersey steers had a dressing percentage of 59.59%. However, purebred Jersey steers consuming the low forage diet (12% DM basis) had live BW of 479 kg with a HCW of 291 kg which equals 60.67% dressing percentage. Both groups of steers had the same amount of internal fat with 2.08% and 2.34% for the high forage diet and low forage diet, respectively. Purebred Jersey steers that consumed the reduced forage diet recorded a 71.18 cm^2 LM area while the high forage steers recorded a 68.34 cm^2 LM area. Additionally, steers that consumed the high forage diet had less backfat than the low forage diet steers (6.30 vs. 7.49 mm, respectively). Yield grade score with the high forage diet steers having a 2.47 YG value while the low forage diet steers recorded a 2.61 YG value. Steers that consumed the low forage diet did have an advantage in quality grade as low forage diet steers recorded a marbling score of 621 (500 = small, 600 = modest, etc.) and a USDA quality grade of 10.74 (10 = low choice, 11 = moderate choice, etc.) where their counterparts consuming the high forage diet had a marbling score of 572 and USDA quality grade of 10.13.

Lehmkuhler and Ramos (2008) reported Jerseys having a HCW of 208 kg and dressing percentage of 54.8%. Steers had a 59.0 cm^2 LM area while having 0.35 cm of backfat thickness, but also had a 5.7% trim loss. However, purebred Jersey steers were acceptable for their marbling score (563; 500 = small) and YG (2.1) values. Lehmkuhler and Ramos (2008) report HCW of 273kg and 276 kg for the high energy diet vs. the phase feeding protocol, with dressing percentages of 56.1% and 56.8%, respectively. Additionally, they also noted an increase in trim of 7.3% for the high energy steers and 7.4 for the phase feeding protocol steers. The lower dressing percentage reported by Lehmkuhler and Ramos (2008) could have been partly due to the increased amount of visceral fat that was observed. Steers that consumed the high energy diet for the duration of the feeding period had smaller LM area (73.9 cm^2) whereas the phase fed steers had a 75.9 cm^2 LM area. Steers on the phase feeding protocol, had a reduced numeric backfat thickness (0.30 cm) compared to the steers on the high energy diet (0.41 cm). However, the steers consuming the high energy diet had an advantage in marbling score over their phase fed counterparts (619 vs. 566; 500 = small, 600 = modest, etc).

Jersey Crossbred Data. In addition to the growth and efficiency data from the 1970 MARC data, Koch et al. (1976) also reported carcass composition and quality aspects. Jersey crossbred (Jx) steer carcasses were the lightest at 269 kg on average, with Charolais cross cattle (**Cx**) having the heaviest carcasses at 314 kg (Koch et al., 1976). With regards to dressing percentages, the Jx cattle dressed out at 62.7% while the remaining breeds had an average dressing percentage of 63.5%, when corrected to a constant HCW. Additionally, Jx cattle had the greatest percentage of KPH (6.0%; 16.8 kg) and required the greatest percentage of fat trimming (24.7%; 68.8 kg) on a constant hot carcass weight basis. With an above average percentage of fat, retail product percentages for Jx cattle only yielded 63% (176.1 kg) of product while Angus x Hereford crosses had 65% and Cx had 72.5% with the average of the study having a 68%.

Therefore, with a dressing percentage of 56.5% and hot carcass weights of 272 kg and greater, Jersey cattle must achieve final live weights of at least 482 kg in order to minimize any discounts in the commodity beef market. These reported poor growth and carcass characteristics have resulted in Jersey genetics being discriminated against among cattle feeders, creating a weak marketing option.

Meat Quality Characteristics

Jersey genetics can add or improve several traits in the commodity marketplace: 1) grading and 2) eating experience. Carcass quality attributes of Jx calves ranked among the top in quality grade, marbling, and 2nd behind South Deven-crossbred in Warner-Bratzler shear (by 0.03 of a kg) in the MARC data from the 1970s. The Jx cattle had the greatest longissimus fat of all breeds (8.2% at a common 288 kg HCW; 6.7% when age and DOF were constant) and the greatest marbling score (13.81; 15, 14, 13 = modest; 12, 11, 10 = small; etc.) (Koch et al., 1976). It has been shown that Jersey cattle can compete with beef breeds in regards to meat quality by their ability to consistently reach the choice quality grade (Koch et al., 1976; Pitchford et al., 2002). Additionally, Marshall (1994) ranked the Jersey breed atop all other breeds in marbling capabilities, showing that they can achieve a marbling score of 614 on the marbling scale (slight = 400 to 499, small = 500 to 599, etc.). Jiang et al. (2013) reported that steers achieved marbling scores of 568.3 and 661.0 when analyzed by block at initial BW for light and heavy steers, respectively. Steers consuming two different levels of concentrate during the finishing phase had marbling scores of 589.5 for F70 steers (70% concentrate) and 639.8 for F85 (85% concentrate).

Another aspect that can be used to predict eating experiences of consumers is tenderness, which is estimated by shear force. These values have been shown to be inversely correlated to the tenderness of meat products (Koch et al., 1976). It has been documented that Jersey cattle have the lowest values of shear force among dairy (i.e. Holstein and Friesians) and beef genetics (Angus), and has continually been ranked at the top in categories for juiciness and overall flavor (Purchas and Burton, 1976; Ramsey et al., 1963; Marshall, 1994; Koch et al., 1976). Low shear force values and overall tenderness is in part due to the overall chemical structure and makeup of fat. Pitchford et al. (2002) stated that the melting point (reflective of the fatty acid profile) of fat in beef carcasses determines how hard or soft the fat is and has an influence on the taste of beef. Additionally, to determine at what temperature the fat will melt is indicative of the fatty acid components (Pitchford et al., 2002). Pitchford et al. (2002) looked at fat melting points and fatty acid composition and found that Jersey had a melting point of 37.1°C with Wagyu cattle having a similar melting point of 37.8°C; however, the other breeds (i.e. Angus and Charolais) had a 6% higher melting point. Fatty acid profiles can play a critical role in overall consumer acceptability. Tenderness and fatty acid profiles are of importance especially as meat product is shipped to oversea markets such as Japan.

Potential Health Benefits of Jersey Beef

As consumers of beef products become more health conscious, they tend to seek a product that has positive health benefits (Naude and Boccard, 1973; Schaake et al., 1993 and Barton and Pleasants, 1997). One of many benefits from eating beef is the high levels of conjugated linoleic acid (**CLA)** (Chin et al., 1992). This is important because CLA contains a mixture of octadecadienoic acids (Lin et al., 1995), especially of the cis-9 and trans-11 isomers (Chin et al., 1992) which have received notable attention due to their anti-carcinogenic properties. Humans can increase their CLA intake by consuming food products of ruminant origin (i.e. meat and milk) (Dhiman et al., 1999). Conjugated linoleic acids can be found in plant oils and non-ruminant tissue (i.e. chicken and pork) but at lower levels (Lin et al., 1995) compared to ruminant based products. Jersey beef needs to be marketed for its positive attributes that are encountered during the eating experience in order to gain extra premiums to offset the growth and performance inefficiencies in the feed yard. This can be accomplished through niche markets for purebred Jersey beef, where the health benefits can become "value added" and help increase the health benefits that one would receive through consumption of beef in their diets.

FEASIBILITY OF PUREBRED JERSEY CATTLE FOR BEEF PRODUCTION

Jersey beef can be a viable option and contribute to the overall amount of beef in the commodity market. It also has several positive attributes that can be gained such as the overall quality aspects of the meat (tenderness, taste appeal, fatty acid profile). However, Jersey steers must meet the minimum requirements for live weight due to their expected low dressing percentages. There needs to be more research that focuses on how purebred Jersey steers grow, develop and accrete muscle (protein) and fat, especially visceral fat, in order to determine the most effective and efficient practices of feeding them to meet the current beef industry guidelines. Additional research and studies need to be conducted that look at the potential for niche markets, where Jersey beef can take advantage of the positive attributes (marbling, tenderness and taste profiles) that they lend to the beef industry. If developed properly, the Jersey industry can garner premiums for their beef as opposed to receiving discounts on the open market.

The beef industry currently is utilizing multiple tools, such as heterosis, anabolic implants and synthetic β-AA, with regards to production of beef and has successfully implemented their use into the feeding of Holstein steers. In addition to current growth and development research, more research needs to be done in order to find the most beneficial times at when anabolic implants can be utilized in the Jersey beef production in order to increase their profitability and studies need to be conducted using synthetic β-AA on Jersey steers to increase the overall muscle volume of the steer, as they can sacrifice marbling to produce a heavier muscled carcass for beef production.

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CHAPTER 2

Growth and Carcass Merit of Purebred Jersey Steer Calves Finished on Grain-based Diets at Two Different Energy Levels

G. L. Tschida, C. J. Mueller, and V. B. Cannon

ABSTRACT: Twenty purebred Jersey steers were used to evaluate lifetime growth and carcass development while finished on different caloric-density diets. Steers were grouped by weight (LIGHT, HEAVY) then randomly assigned to either a 70% (F70) or an 85% (F85) concentrate finishing diet. Growth, intake, and carcass data were analyzed as a randomized complete block design with initial BW groupings (LIGHT and HEAVY) as the blocking factor. Growth, intake, and carcass data were analyzed as a randomized complete block design with initial BW groupings (LIGHT and HEAVY) as the blocking factor. Data from the growing phase (169 d) were analyzed as LIGHT (77 ± 8 kg) versus HEAVY (97 ± 8 kg) only, since finishing treatments were yet to be applied. Data from the finishing phase were analyzed as LIGHT versus HEAVY and F70 verses F85. Daily rations were distributed by pen during the growing phase and individually during the finishing phase. Growing phase ADG was not different (P>0.19) between LIGHT (0.89 kg/d) and HEAVY (0.97 kg/d) steers, respectively. The LIGHT calves consumed (P<0.05) less DMI per day versus HEAVY calves during the growing period. During the finishing phase ADG for F85 steers (0.91 kg/d) was greater (P<0.05) than F70 steers (0.82 kg/d). Intake was not different (P>0.10) between F70 (7.8 kg) and F85 steers (7.7 kg), whereas G:F was lower (P<0.05) for F70 steers (0.11 kg/kg) compared to F85 steers (0.12 kg/kg). Ultrasonography was used to track carcass changes and showed no differences (P>0.10) in backfat accretion (+0.42 cm vs +0.42 cm), muscle depth (+1.30 cm vs +1.46 cm) or marbling score (+166 units vs +177 units) for F70 and F85 steers, respectively. Ultrasound indicated that changes in muscle depth plateaued around 284 DOF, while fat deposition continued to increase. Actual carcass data showed no differences (P>0.10) in backfat (0.61 cm vs 0.59 cm) or KPH (2.48% vs 2.58%) between F70 and F85 steers, respectively. Ribeye area for F85 steers (60.9 cm^2) was greater (P<0.05) than F70 steers (54.3 cm^2), whereas marbling score tended to be greater (P<0.10) for F85 steers (640, modest) versus F70 steers (590, small). Calculated yield grade (2.97 and 2.77) and retail yield (50.0% and 50.4%) were not different (P>0.10) between F70 and F85 steers, respectively. Jersey steers have the ability to produce highly marbled carcasses, but carcass quality must be valued against low growth efficiency.

Key Words: Carcass, Growth, Jersey

INTRODUCTION

Jersey dairy producers marketing their steer offspring receive minimal compensation for their product due to a lack of demand by both beef feeders and saturated veal markets. These constraints have resulted in the majority of Jersey steer calves being euthanized, which may lead to potential social outcry. A similar situation in Denmark resulted in 59% of Jersey bull calves being euthanized due to their expected poor production and marketing difficulties (Nielson and Thamsborg, 2002). Compared to current beef industry standards and economics purebred Jersey steers have under-performed resulting in these animals being overlooked for red meat production. Current production practices are aimed at generating beef carcasses capable of obtaining low choice, 1.0 cm or less of backfat, and carcass weights between 272 and 408 kg (BIF, 2010). Current feeding practices comingle Jersey steers with Holsteins; therefore, nutrient management tends to reflect the larger-framed Holsteins. Unfortunately, comingling the light-muscled Jerseys with Holsteins produces an over-conditioned carcass, which is susceptible to carcass discounts.

Marshall (1994) pooled data from nine studies and found that Jersey cattle achieved the highest marbling score compared to other breeds of cattle (beef and dairy); evidence that purebred Jerseys are capable of producing a high quality carcass. Additionally, Pitchford et al. (2002) stated that Jersey cattle accumulated greater amounts of intramuscular fat compared to other breeds, which is softer due to the fatty acid profile. Consequently, the consumer should have a more flavorful and tender cut of meat, which could enhance their eating experience. Therefore, the following study was developed to provide clarity in growth performance and carcass development of purebred Jersey steers from weaning, though harvest while finished on two different energy levels.

MATERIALS AND METHODS

All procedures within were approved by the Oregon State University Animal Care and Use Committee. (ACUP No. 3572).

Animals, Housing, and Health Management

Twenty head of purebred Jersey bull calves were born within a two week period on a commercial dairy operation located in Tillamook, Oregon. Calves were individually raised and fed a commercial milk replacer diet according to farm protocol from birth until 10 wk of age. During this period, all calves were dehorned, castrated, dewormed, and received their initial respiratory vaccinations (Bovi Shield Gold FP5- L5, One Shot; Pfizer Animal Health, Exton, PA). Calves were transported 146.5 km to Oregon State University's beef cattle feeding facility (Corvallis, Oregon) and acclimated to the facilities and receiving diet (Table 2.1) for 34 d. Steers were housed in a confined, naturally ventilated, pole barn structure with unlimited access to water. Pens were 4.6 × 14.6 m with the feeding and loafing area under cover. Upon arrival, steers were weighed and randomly allotted to four pens (5 hd/pen). Shrunk BW were obtained on steers 10 d prior to trial commencement for allocation of steers into trial blocks and treatments. Based on Univariate analysis of shrunk BW, steers were blocked into light (**LIGHT**; 77.4 ± 2.48 kg) and heavy (**HEAVY**; 96.7 ± 2.53 kg) pens. Within the BW blocks, steers were randomly assigned to their future finishing energy treatment (Figure 2.1). Finishing treatments were stratified across pens to reduce pen effects. Steers were moved into their trial pens 3 d prior to commencement of the growing period.

Steers were vaccinated at 99 days on feed (**DOF**) for respiratory disease (Bovi-Shield GOLD 5; Pfizer Animal Health, Exton, PA) and clostridial bacteria (BAR VAC 7/SOMNUS; Boehringer Ingelheim Vetmedica, INC., St. Joseph, MO); along with parasite control (Noromectin Plus; Norbrook Inc., Lenexa, KS). A booster vaccination for respiratory disease and clostridial bacteria were administered at 123 DOF as directed by label recommendations.

Calves were monitored daily at feeding (0800 h) and at 1400 h for any health problems and treated according to approved site procedures. Aside from a short episode of coccidiosis within two weeks of arrival, steers remained active and healthy throughout the study.

Nutritional Management

Upon arrival to OSU beef facilities, calves were fed 2.02 kg (DM basis) of ground grass hay (10% CP) top dressed with 0.40 kg (DM basis) of protein pellet (29.6% CP) for 13 d post arrival. Calves were then fed the growing diet (**G1**) for 21 d for diet adaption before trial commencement.

Growing Phase. Throughout the growing phase, steers were group fed a common growing diet (Table 2.1). Steers were fed the G1diet from trial commencement until steers weighed approximately 159 kg (LIGHT = 102 DOF; HEAVY = 64 DOF). In order to better match calves body size, protein and DM intake; steers received a secondary growing diet (**G2**) until the conclusion of the growing phase (Table 2.1). The growing diets were fed during the growing phase to allow the monitoring of growth patterns of steers without the influence of different nutrient inputs. Growing diets were based on NRC (2000) guidelines for beef steers of similar BW.

Due to the initial size of the steers, calves were pen fed in rubber troughs to allow steers complete access to feed without hindrance. Steers were pen fed once daily (0800 h) with orts being quantified and discarded the following morning. At the time orts were quantified, bunks were scored (Pritchard, 1994) and adjusted for the next feeding. Feed calls were assigned to continually challenge steer intake in order to maximize daily DMI, which has an effect on feed efficiency and ADG (Pritchard, 1994). A Calan Broadbent feed gate (American Calan, Inc., Northwood, NH) system was installed for individual consumption throughout the finishing phase. An adaption period of 42 d was allowed for Calan gates prior to the start of the finishing phase on 172 DOF. Due to limited trough space and increased feed consumption, steers were fed twice daily (0800 and 1700 h) with equal amounts of feed at each feeding on 154 DOF. Diets were batch mixed every 7 to 10 d and delivered to the feeding barn for storage and distribution.

Finishing Phase. Finishing diets consisted of a moderate concentrate diet (**F70**; n = 10 hd) consisting of 70% concentrate and 30% forage, and a high concentrate diet (**F85**; n = 10 hd) consisting of 85% concentrate and 15% forage (Table 2.1). Finishing diets were developed to determine if the caloric density had an influence on DOF, along with rate of protein (lean muscle) and fat accretion. Finishing diets were based on NRC (2000) guidelines for finishing beef steers of similar size.

Steers were switched to their respective finishing diets on 168 DOF and were transitioned to assigned finishing diets by caloric intake adjustment. Steers were individually fed twice daily (0800 and 1700 h) using Calan gates with equal amounts of feed at each feeding. Orts were quantified and discarded the following morning. As the presence of fines increased in daily orts, cane molasses was included in the diet at 5% (DM basis) to help improve ration integrity (Table 2.1). Steers were switched to rations containing molasses (F70M and F85M) at 269 DOF. At time of harvest, respective steers had their Calan gate deactivated to prohibit feed consumption for 15 h to determine final shrunk BW.

Measures of Growth and Development

Growth data was collected every 28 d to monitor performance. Feed was removed from pens starting at 1600 h the day prior to collections, and throughout the collection day. Data collection was divided into two segments for each collection period. Morning collections started at 1000 h; and consisted of hip heights (HH), shrunk BW and ultrasonography. Hip heights were taken according to Beef Improvement Federation (**BIF**) Guidelines (2010). Beef Improvement Federation Guidelines (2010) state that once hip height measures are gathered, you need to transform those values into a frame score; however, there are no current frame score models available for Jersey steers and the models available for beef steers and heifers do not accurately portray the frame size of purebred Jersey steers. Therefore, a ratio of body weight-to-hip height was used to provide a depiction of frame size for each steer. Carcass ultrasound measurements were acquired starting at 145 DOF and collected every 28 d through harvest. Ultrasonography measurements were obtained using an ALOKA 500 console (model SSD-500V, Aloka

CO., LTD, Wallingford, CT) and a 125 mm linear body composition probe (model UST-50116-3.5, Aloka CO., LTD, Wallingford, CT). Ultrasound measurements were interpreted using the CPEC software program (version 2.0, Cattle Performance Enhancement Company, Oakley, KS). To prepare the steers for ultrasonography, the scan area between the 11^{th} and 13^{th} rib section was clipped and vegetable oil was applied for proper penetration of the sound waves. A single scan was taken longitudinal to the center of the LM. Once the image was captured, the software returned values for backfat depth, LM depth, and marbling score. Ultrasound measurements along with BW were used to determine harvest date.

Afternoon data collections commenced at 1400 h. To assist in determining body composition of steers, urea dilution procedures outlined by Preston and Koch (1973), along with Rule et al. (1986) were employed. Steers were restrained with a rope halter and a 10 × 3 cm area was clipped over the jugular vein region. A 16 gauge, 6.35 cm SurFlash polyurethane intravenous (**IV**) catheter (Terumo Medical Corporation, Ann Arbor, MI) was inserted into the jugular vein. A 94 cm IV extension set (Baxter Healthcare Corporation, Deerfield, IL) was attached to the catheter to allow for any unplanned movement by the steer while obtaining an initial blood sample and infusion of urea solution. The steer was then infused with a predetermined (0.75 ml/kg of shrunk BW) volume of 20% urea solution over a 2 min period, followed by an additional blood sample taken 12 min post-infusion. Both initial and post-infusion blood samples were collected into 10 ml sterile K_2 EDTA vacutainer tubes (Becton, Dickson and Company, Franklin Lakes, NJ). The blood samples were immediately stored on ice in a cooler until collections were completed. Blood samples were then centrifuged at 2000 × *g* for 30 min, and plasma was harvested and stored in 12 × 75 mm polypropylene culture tubes at -20°C until plasma urea nitrogen (**PUN**) analysis. Plasma urea nitrogen analysis was completed according to the methods described by Fawcett and Scott (1960), along with Chaney and Marbach (1962). When centrifuging blood samples, various issues with hemolysis were observed; therefore, future protocols should suggest a lower centrifuge "g-force" to limit hemolysis occurrence for Jersey blood samples.

Urea space (**US**) values were then used to determine the percentage of carcass lipid, carcass protein, carcass water, carcass empty body water (**EBW**) and carcass empty body fat (**EBF**) of the Jersey steer. Although all formulas published by Rule, et al. (1986) were processed and taken into consideration, formulas that depicted the most accurate predictions were those formulas that included US percentage and BW within the formula. The formulas that were used to determine carcass lipid, protein, water, EBW and EBF are presented in table 2.3.

Once ultrasound measurements for individuals indicated marbling scores of 500 or greater, they were scheduled for harvest. Final measurements were obtained 18 h prior to harvest. To reduce stress at harvest, steers were not separated from pen mates, but were locked out of their respective Calan gate and had access to fresh water during the shrink period. On the morning of harvest (0730 h), steers were weighed and transported 0.60 km to Oregon State University's Clark Meat Center for processing.

Carcass Data Collection

Carcass measurements were collected following a 48 h chill period by two trained university personnel. Due to the subjectivity of carcass data collection, the average of the two trained university personnel was used to quantify carcass traits. The left side of each carcass was cut between the 12th and 13th ribs to allow for carcass measurements. A 20 min bloom time under halogen lighting was allowed prior to carcass data being collected. Measurements gathered included LM area, 12th-rib fat thickness, percentage of KPH, marbling score on a nine degree marbling scale (BIF, 2010), and the presence of fat color (either white or yellow). For statistical analysis, final measurements were considered the average of the two evaluators. Once carcass measurements were taken, 9-10-11 rib sections were then removed from the left side to undergo additional meat quality and taste attribute analysis.

Statistical Analysis. Growth, intake, and carcass data were analyzed as a randomized complete block design with initial BW groupings (LIGHT and HEAVY) considered the blocking factor (Cochran and Cox, 1992). Ultrasound data and urea dilution data were analyzed as repeated measures over time using steer within treatment x block as the error term. Growing data were analyzed as LIGHT vs. HEAVY with pen as the experimental unit. Finishing data were analyzed using the effects of treatment, block, and all possible interactions; and steer was considered the experimental unit. Treatment and block means were separated using least square means procedures and were considered significant at the $P < 0.05$ level. Tendencies were identified for alpha-levels between 0.05 and 0.15 for ultrasound data, and between 0.05 and 0.20 for urea dilution data. All analyses were performed using GLM procedures of SAS (version 9.1, SAS Institute, Inc., Cary, NC), except for repeated measures (MIXED procedures).

RESULTS

Growing Phase

The growing phase lasted a total of 169 d. The HEAVY steers were heavier (P = 0.022) at the beginning of the growing period and retained their weight advantage, gaining the same (P = 0.19) per day, over LIGHT steers throughout the growing period (Table 2.2). Additionally, HEAVY steers had greater height at the beginning (P = 0.044) and continued growing at the same rate (P = 0.31) keeping their height advantage at the conclusion of the growing phase (P = 0.050) over their LIGHT counterparts. Steers in the HEAVY block tended (P = 0.07) to have greater frame ratios (Figure 2.2) and were heavier (P = 0.02) versus the LIGHT steers at the beginning of the growing phase (Table 2.2). Although HEAVY steers consumed more (P = 0.004) daily DM than the LIGHT steers, they were not more efficient (P = 0.27) in converting the available energy into BW (Table 2.3).

Urea dilution values from the 30 DOF collection was not reported due to values being biologically unreasonable, primarily with values greater than 100. Variability was also noted by Rule et al. (1986) on young stock. As the steers progressed on feed, the HEAVY steers tended (P = 0.132) to have greater US percentages, although there were no differences ($P \geq 0.35$) for carcass lipid, protein, water, EBW and EBF estimates (Table 2.4). At the conclusion of the growing phase, there were no differences (P = 0.35) observed between the LIGHT and HEAVY block for US. However, tendencies ($P \leq 0.130$) were observed for the carcass lipid, protein, water, EBW and EBF estimates indicating that the HEAVY steers were stabilizing on protein accretion and moving available nutrients to favor lipid synthesis (Table 2.4).

Finishing Phase

LIGHT vs. HEAVY. The HEAVY steers were 8% heavier ($P = 0.005$) at harvest than LIGHT steers, and required 11 fewer DOF ($P < 0.001$) (Table 2.2). Although LIGHT and HEAVY steers added HH at similar rates ($P = 0.23$), HEAVY steers were 3.2 cm taller ($P = 0.059$) than LIGHT steers. Additionally, HEAVY steers had greater BW ($P \leq 0.02$) in relation to their frame throughout the entire finishing phase (Figure 2.2). Even though LIGHT and HEAVY steers had similar ($P = 0.18$) ADG and gain efficiencies ($P = 0.44$), the HEAVY steers tended to consume more ($P = 0.068$) daily DM than their LIGHT counterparts (Table 2.4). This is understandable as HEAVY steers would require more daily DM due to a greater metabolic BW over the LIGHT steers.

Steers within the HEAVY and LIGHT block had similar ($P \geq 0.137$) ultrasound backfat from 144 to 284 DOF, but at 305 DOF HEAVY steers had a greater ($P = 0.023$) ultrasound backfat compared to their LIGHT counterparts (Figure 2.3). Additionally, HEAVY steers had 29% ($P = 0.031$) and 32% ($P < 0.001$) more ultrasound backfat at 368 DOF and at the pre-harvest scan, respectively compared to LIGHT steers. Steers within the HEAVY block had greater ($P = 0.044$) ultrasound LM depth at trial start than LIGHT steers; however, throughout the next 84 d, no differences ($P \geq 0.16$) were observed between the two groups (Figure 2.4). The HEAVY steers had a greater ultrasound LM depth than LIGHT steers at the 284 DOF ($P = 0.006$) and 368 DOF ($P = 0.025$); and tended ($P = 0.13$) to be greater at pre-harvest collection. Initial ultrasound marbling scores were 7% greater ($P = 0.004$) for HEAVY vs. LIGHT steers. The HEAVY steers had a tendency ($P \leq 0.13$) to return greater ultrasound marbling scores than LIGHT steers on the 200 and 305 DOF collection, although there were no differences ($P \geq 0.269$)

observed between BW groups on 172, 228, 256, 284 DOF (Figure 2.5). The HEAVY steers had greater ultrasound marbling scores (P = 0.034) compared to LIGHT steers at 340 DOF and a 10% marbling advantage (P = 0.006) over LIGHT steers at 368 DOF. However, at the pre-harvest scan both LIGHT and HEAVY steers had similar (P = 0.36) ultrasound marbling scores of 5.25 and 5.39, respectively.

Throughout the finishing phase no differences ($P \geq 0.21$) were observed for US and body composition estimates when the data was compared by BW group until 340 DOF (Table 2.5). The LIGHT steers tended (P = 0.13) to have a greater US estimate over their HEAVY cohorts at 340 DOF with a US estimate of 26.16 and 13.58, respectively, indicating that more of the solution was absorbed in lean tissue mass. The greater US estimate returned by the LIGHT steers is understandable as they tended (P = 0.13) to have less carcass lipid (P = 0.014) and EBF estimates (P = 0.013) (Table 2.5). Additionally, it is apparent that HEAVY steers have started partitioning more energy to lipid production and stabilized protein synthesis at the 340 DOF collection as HEAVY steers are indicating significant ($P \leq 0.018$) lower estimates for carcass protein, carcass water and EBW (Table 2.5). At pre-harvest collection, LIGHT and HEAVY steers were similar ($P \geq 0.22$) in body composition based on US, carcass lipid, carcass protein, carcass EBF, and carcass EBW estimates (Table 2.5).

F70 vs. F85. The F85 steers were 5% heavier (P = 0.032) and 9% more efficient (P = 0.042) at utilizing the available dietary energy to add overall mass and tended (P > 0.08) to have greater weight per unit of HH than F70 steers (Table 2.2). Days on feed between the two treatments did not differ (P = 0.31). It was observed that as the steers reached 341 DOF the F85 steers tended ($P \leq 0.09$) to add more BW per unit of HH compared to the F70 steers until harvest. This was further supported as the F85 steers gained more BW ($P = 0.019$) per day while consuming similar ($P = 0.79$) amounts of daily DM (Table 2.2). Because the F85 steers gained more while consuming the same amount of feed, the resulting gain efficiency favored the F85 steers ($P = 0.042$) over their F70 counterparts. The additional gain efficiency observed may be the result of more energy being partitioned for lean muscle growth over fat deposition.

Few differences were observed between finishing diets regarding ultrasound measurements. Both F70 and F85 steers had similar ($P \geq 0.21$) ultrasound backfat and LM depth estimates from 144 DOF through harvest (Figures 2.3 and 2.4, respectively). Additionally, ultrasound marbling scores were only different ($P = 0.024$) at 340 DOF, with F85 steers having a 7% greater ($P = 0.024$) marbling score estimate versus F70 steers (Figure 2.5).

When analyzing US and body composition percentages, finishing treatment resulted in similar ($P > 0.20$) growth rates until 284 DOF, when F85 steers tended to have a 130.5% greater ($P = 0.118$) US estimate than the F70 steers. Additionally, the F85 steers tended to have a 7% advantage ($P = 0.160$) in carcass protein, a 5% greater ($P = 0.193$) amount of carcass water and 6% greater carcass EBW ($P = 0.176$) over the F70 steers, indicating a greater amount of lean tissue accumulation as a percentage of body weight. This was further supported by the F70 steers tending to carry a greater amount of carcass lipid ($P = 0.165$) and carcass EBF ($P = 0.167$) over the F85 steers.

Both F70 and F85 steers continued to partition nutrients at similar rates ($P \geq 0.33$) when comparing US and body composition estimates until pre-harvest. As steers continued on feed, F85 steers started shifting available dietary nutrients from lean tissue growth to lipid cell accumulation. At the time of pre-harvest collections, the F85 steers tended to have a greater amount of lipid content present as it related to their overall body composition by having a greater percentage of carcass lipid ($P = 0.184$) and carcass EBF ($P = 0.181$) over the F70 steers (Table 2.5). The F70 steers had the greater amounts of carcass water ($P = 0.152$) and carcass EBW ($P = 0.170$) over the F85 steers at the pre-harvest collection. Additionally, F70 steers tended to have a greater ($P = 0.191$) amounts of carcass protein over their F85 counterparts at pre-harvest. This would indicate that the F85 steers will carry a greater percentage of fat as it relates to the carcass composition, which includes both internal and external fat.

Carcass Merit

LIGHT vs. HEAVY. Steers in the HEAVY block had 12.5% heavier ($P < 0.001$) HCW and 4% greater dressing percentage ($P < 0.001$) compared to their LIGHT counterparts (Table 2.6). Additionally, HEAVY steers had a 7.2 cm^2 REA advantage ($P = 0.009$) with a 16% greater ($P = 0.002$) marbling score over the LIGHT steers (Table 2.6). Although HEAVY steers had an advantage in REA and HCW, they were no different ($P = 0.89$) in the proportion of REA to HCW indicating that they were proportionally similar in carcass muscling. The HEAVY steers had greater ($P = 0.044$) backfat depth and a 20% greater ($P = 0.031$) KPH estimate compared to LIGHT steers; yield grade ($P = 0.33$) and retail yield percentage ($P = 0.30$) was not different (Table 2.6). Additionally, HEAVY steers generated greater value ($P = 0.004$) per head at $882.93 versus $758.65 for LIGHT steers (Table 2.6); primarily due to their advantages in HCW and dressing percentage which results in greater red meat yield.

F70 vs. F85. When comparing effects of finishing diets, F85 steers had a 6% heavier (P = 0.042) HCW and a 7 cm^2 greater (P = 0.015) ribeye area over their F70 counterparts (Table 2.6). Although there were differences in HCW between F70 and F85 treatments, dressing percentage was not affected (P = 0.60) by the finishing diet. Furthermore, F85 steers did not (P = 0.25) have an advantage in ribeye area-to-hot carcass weight (**REA: HCW**) ratio indicating that the steers were proportionally the same. Finishing diet had no impact on backfat (P = 0.84), KPH (P = 0.67), yield grade scores (P = 0.33), or retail yield percentages (P = 0.35). Steers consuming the more energy dense diet (F85) tended (P = 0.060) to have increased levels of marbling and returned 10% more carcass value over the steers consuming the F70 diet ($860.49 vs. $781.10, respectively) (Table 2.6).

DISCUSSION

Growing Phase

Due to the small stature and frame of the Jersey breed, sorting these cattle by frame and BW is important to help match the future growth and marketing needs of Jersey steers. In our study, having an additional 25% of BW prior to the growing period corresponded to greater ADG and allowed more development of lean tissue growth in preparation for the finishing period. Although the HEAVY steers did consume more feed than their LIGHT counterparts, larger framed cattle have a greater requirement for growth (NRC, 2000). Urea dilution data are in agreement that the Jersey steers are of similar body composition early on in the trial, but as DOF increased HEAVY steers were able to increase partitioning of available nutrients to lean tissue growth and overall body mass by the completion of the growing period. Sorting by BW after weaning from milk consumption allows producers to group and market similar statured cattle closer together, which will benefit cattle feeders as they move into the growing phase and eventually into the finishing phase of feeding.

Finishing Phase

LIGHT vs. HEAVY. Steers within the HEAVY group, continued to have an overall BW and HH advantage over their LIGHT group counterparts, which allowed them to carry more relative body mass to harvest. As expected, the HEAVY steers, consumed greater amounts of feed, although there were no differences in ADG, G:F, and cost of gain versus the LIGHT steers. Therefore, HEAVY steers were able to provide more pounds of product without affecting the cost of gain versus their LIGHT counterparts. The HEAVY steers had a greater ultrasound LM depth versus LIGHT steers at 284 and 340 DOF, which corresponds to the greater REA observed on the carcass. It should be noted that the LIGHT steers continued to develop ultrasound LM depth in the last 120 d while the HEAVY steers tended to plateau in LM depth accumulation after 284 DOF. Ultrasound backfat of the Jersey steers continued to increase as DOF increased on the finishing ration. Although the increase was not linear, both LIGHT and HEAVY steers had similar backfat accretion rates. Ultrasound marbling scores were different between LIGHT and HEAVY steers at 145 DOF, however, scores were similar thereafter until 340 DOF when HEAVY steers differentiated themselves with greater estimates of marbling. Overall, the ultrasound estimates indicate a stabilization of LM size, while backfat and marbling score estimates increased indicating that more available nutrients are being shifted to lipid deposition.

Although ultrasound marbling was similar at pre-harvest, carcass marbling scores followed the ultrasound trend starting after 340 DOF indicating that they were partitioning more of the available energy to lipid deposition. Urea dilution data supports lipid changes as DOF increased, with carcass lipid increasing and subsequently carcass water decreasing. As supported by the ultrasound measurements for marbling score estimates, body composition estimates would suggest that at 340 DOF HEAVY steers have reduced carcass protein estimates while carcass lipid and carcass EBF values are greater compared to their LIGHT counterparts. This change would suggest that Jersey steers are completing lean muscle development at 340 DOF and increasing partitioning of available energy to lipid accumulation. It should be noted that pre-harvest urea dilution collection from steers across all BW groups are not different in carcass lipid and carcass EBF, which indicates steers were harvested at equal fat end points. Ultimately, the increased fat deposition allowed the HEAVY steers to be ready for harvest at an earlier date, which decreased DOF and reduced total feed costs over their LIGHT counterparts.

In order to receive more profit from a carcass standpoint, certain benchmarks must be achieved in order to obtain the greatest value from a commodity beef market. The benchmarks set forth are that HCW must range between 272 and 408 kg, a REA of 71 cm^2, and 1.02 cm or less of backfat to achieve a 3.0 yield grade or less. Although, the LIGHT and HEAVY groups all fell below these benchmarks, HEAVY steers were able to minimize the amount of discounts received. Steers in the HEAVY group were within 1% of the HCW benchmark as opposed to within 13% for LIGHT steers. In regards to dressing percentage, steers in the current trial had a range of 55.9 to 58.2%, which is in agreement with Lehmkuhler and Ramos (2008). Lehmkuhler and Ramos (2008) also observed greater amounts of visceral fat which was supported in the current study with steers having greater than 2% KPH. The HEAVY steers had 24% more visceral fat than LIGHT steers, which would equate to a greater portion of carcass trim. Steers within the HEAVY group had a 13% advantage in REA versus LIGHT steers, but still were 10 cm^2 less than the industry benchmark. Feedyard management must be cognizant of the fact that with Jersey's smaller REA and their ability to partition fat at the subcutaneous and internal level, yield grade discounts are likely. Although both the LIGHT and HEAVY steers had a difficult time achieving the needed pounds of product, all steers achieved the quality grade benchmarks.

F70 vs. F85. There were no differences in starting BW and HH between the F70 and F85 steers as they entered the finishing period. Steers consuming the F85 diet had a 9% improved gain conversion and an 11% greater ADG resulting in a 5.6% final BW advantage for the F85 steers over the F70 steers. The added BW advantage would result in an increase in net carcass value which is supported by frame ratios. Steers in both treatments continued to grow at the same rate, until 340 DOF when the F85 steers tended to have greater relative body mass versus their F70 counterparts until harvest. However, F85 steers did not show an advantage over their F70 cohorts when evaluating the ultrasound LM depth estimates, which indicates the steers would be similar in overall muscling. At harvest, F85 steers held an advantage in REA over the F70 steers which supports the differences in frame ratio. Additionally, as with the growing phase, F85 and F70 ultrasound BF estimates followed the same patterns throughout the finishing phase even though they were not different. Backfat estimates and marbling scores increased at similar accretion rates. As DOF increased and steers approached target endpoint, ultrasound marbling estimates are not different between finishing treatments. However, steers that consumed the higher energy diet, were able to take advantage of the added nutrients in the ration and partition them to lipid deposition sooner. This was evident as the F85 steers had 8% greater marbling scores at harvest over the F70 steers. Similar results were noted by Arnett et al. (2002) and Hendrickson et al. (1965) when dietary energy increased there were favorable results in regards to carcass characteristics. Urea space estimates were not different, while observed tendencies included the F85 steers having greater estimates for carcass lipid and carcass EBF; while carcass protein, carcass water, and carcass EBW were less, indicating that they would have a greater portion of fat at harvest supporting the increased marbling score.

IMPLICATIONS

More research is needed with Jersey cattle and urea dilution in order to help quantify the variations that were observed in the data. With the additional pounds observed at harvest, Jersey steers finished on a 85% concentrate diet should be able to achieve the carcass benchmarks set forth by BIF Guidelines. With the surplus of available energy in the F85 diet, steers were able to produce more HCW and achieve a greater marble score. Thus the F85 diet should generate a greater return to the net carcass value through increased saleable carcass weight.

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Table 2.1. Diet composition and nutrient analysis of rations consumed by growing and finishing purebred Jersey steers.

	Growing Diets[1]		Finishing Diets[1,2]			
Item	G1[3]	G2	F70	F70-M	F85	F85-M
Ground grass hay, %	30.0	30.0	30.0	30.0	15.0	15.0
Cracked corn, %	10.0	29.9	45.0	42.0	59.0	55.0
Soybean hulls, %	30.0	20.0	--	--	--	--
Protein pellet[4], %	30.0	21.0	25.0	23.0	26.0	25.0
Cane molasses, %	--	--	--	5.0	--	5.0
Nutrient analysis[5]						
DM, %	86.4	86.2	86.3	85.6	86.4	85.7
Crude protein, %	14.4	12.5	12.5	12.5	12.6	12.6
NDF, %	53.0	43.2	26.8	26.0	19.9	19.3
ADF, %	24.9	20.0	11.6	11.3	8.3	8.0
NE_g, Mcal/kg[6]	1.03	1.10	1.13	1.12	1.23	1.22

[1]DM basis.
[2]F70 = 70% concentrate, F85 = 85% concentrate.
[3]Receiving diet.
[4]29.6% protein, 5.6% Ca, 0.8% P, 8.6% Vit. A, 0.4% S, 0.6% Mg, 1.4% K, 556.8% Fe, 225.5% Zn, 261.8% Mn, 52.2% CI, 0.4% Co, 2.2% I, 0.7% Se, 1.3% Vit. D_3, 215.6% Vit. E.
[5]Values based on laboratory analysis and mixing formulation.
[6]Estimated, based on NRC (2000) values.

Table 2.2. Cumulative growing performance of purebred Jersey steers fed two different finishing diets.

	BW group[1]		Finishing diet[2]			*P* - value	
Item	Light	Heavy	F70	F85	SEM	L vs. H[3]	F70 vs. F85
Growing Phase							
Start age, d	123	123	--	--	--	--	--
Start BW[4], kg	77.2	96.5	--	--	0.91	0.022	--
Start HH[5], cm	86.7	91.7	--	--	0.34	0.044	--
DOF, d	169	169	--	--	--	--	--
End BW[4], kg	227.5	260.8	--	--	1.41	0.017	--
End HH[5], cm	112.8	118.3	--	--	0.40	0.050	--
ADG, kg/d	0.89	0.97	--	--	0.01	0.19	--
DMI, kg/d	4.3	5.0	--	--	0.01	0.004	--
G:F, kg/kg	0.04	0.04	--	--	0.0006	0.27	--
Δ HH[5], cm/d	0.06	0.06	--	--	<0.001	0.31	--
Feed COG[6], $/kg	2.74	2.93	--	--	0.04	0.26	--
Finishing Phase							
Start age, d	292	292	292	292	--	--	--
Start BW[4], kg	227.5	260.8	241.5	246.8	5.04	<0.001	0.46
Start HH[5], cm	112.8	118.3	115.3	115.8	0.85	<0.001	0.64
Finishing DOF, d	240	229	235	234	0.88	<0.001	0.31
Final BW[4], kg	429.2	463.6	434.1	458.7	7.41	0.005	0.032
Final HH[5], cm	131.1	134.3	131.8	133.6	1.10	0.059	0.27
ADG, kg/d	0.84	0.89	0.82	0.91	0.02	0.18	0.019
DMI, kg/d	7.3	8.2	7.8	7.7	0.32	0.068	0.79
G:F, kg/kg	0.12	0.11	0.11	0.12	0.004	0.44	0.042
Δ HH[5], cm/d	0.08	0.07	0.07	0.08	0.004	0.23	0.30
Feed COG[6], $/kg	2.41	2.55	2.44	2.53	0.10	0.30	0.52

[1]Blocked by initial BW; LIGHT, HEAVY.
[2]Treatment: F70 = 70% concentrate diet, F85 = 85% concentrate diet.
[3]L = LIGHT, H = HEAVY.
[4]Shrunk BW.
[5]HH = hip height.
[6]COG = cost of gain.

Table 2.3. Published formulas used to determine urea space and carcass composition estimates using urea dilution (US[1]) methods on growing cattle.

Title	Equation
Urea space[2], %	$US\% = \dfrac{\left\{\dfrac{Volume\ infused\ (mL) \times Concentration\ of\ solution\ \left(\dfrac{mg\ of\ Urea - N}{dL}\right)}{\Delta\ PUN^3}\right\}}{Shrunk\ Live\ Weight\ (kg)}$
Carcass lipid[4], %	$CL\% = 21.0 - (0.32\ \times US\%) + (0.05\ \times LW)$
Carcass protein[4], %	$CP\% = 16.7 + (0.07\ \times US\%) - (0.01\ \times LW)$
Carcass water[4], %	$CW\% = 59.0 + (0.18\ \times US\%) - (0.04\ \times LW)$
Carcass EBW[4,5], %	$CEBW\% = 59.1 + (0.22\ \times US\%) - (0.04\ \times LW)$
Carcass EBF[4,6], %	$CEBF\% = 19.5 - (0.31\ \times US\%) + (0.05\ \times LW)$

[1]US = urea space.
[2]From Koch, S. W. and R. L. Preston (1979).
[3]PUN = plasma urea nitrogen.
[4]From Rule et al. (1986).
[5]EBW = empty body water.
[6]EBF = empty body fat.

Table 2.4. Estimated carcass composition of purebred Jersey steers during the growing phase, based on urea dilution.

	BW group[1]		Finishing diet[2]			*P* - value	
Item	LIGHT	HEAVY	F70	F85	SEM	L vs. H[3]	F70 vs. F85
60 DOF							
Urea space, %	8.52	15.01	--	--	0.91	0.44	--
Carcass lipid, %	25.07	24.03	--	--	0.57	0.69	--
Carcass protein, %	15.94	16.18	--	--	0.24	0.67	--
Carcass water, %	55.10	55.44	--	--	0.39	0.82	--
Carcass EBW[4], %	55.54	56.14	--	--	0.43	0.74	--
Carcass EBF[5], %	23.65	22.68	--	--	0.51	0.70	--
124 DOF							
Urea space, %	11.80	24.38	--	--	0.91	0.132	--
Carcass lipid, %	26.50	24.17	--	--	0.51	0.38	--
Carcass protein, %	15.67	16.31	--	--	0.24	0.35	--
Carcass water, %	53.70	54.61	--	--	0.39	0.54	--
Carcass EBW[4], %	54.27	55.69	--	--	0.43	0.44	--
Carcass EBF[5], %	25.12	22.91	--	--	0.51	0.39	--
173 DOF							
Urea space, %	22.93	15.09	17.13	20.92	0.94	0.35	0.68
Carcass lipid, %	25.09	29.25	27.62	26.76	0.53	0.117	0.77
Carcass protein, %	16.02	15.14	15.48	15.67	0.25	0.130	0.76
Carcass water, %	53.99	51.25	52.40	52.80	0.40	0.069	0.81
Carcass EBW[4], %	55.00	51.95	53.19	53.74	0.44	0.096	0.78
Carcass EBF[5], %	23.82	27.90	26.29	25.47	0.52	0.113	0.77

[1]Blocked by initial BW; LIGHT, HEAVY.
[2]Treatment: F70 = 70% concentrate diet, F85 = 85% concentrate diet.
[3]L = LIGHT, H = HEAVY.
[4]EBW = empty body water.
[5]EBF = empty body fat.

Table 2.5. Estimated carcass composition of purebred Jersey steers during the finishing phase, based on urea dilution.

	BW group[1]		Finishing diet[2]			*P* - value	
Item	LIGHT	HEAVY	F70	F85	SEM	L vs. H[3]	F70 vs. F85
229 DOF							
Urea space, %	28.75	25.54	26.97	27.85	0.95	0.71	0.87
Carcass lipid, %	26.45	29.01	27.79	27.68	0.53	0.35	0.97
Carcass protein, %	15.78	15.25	15.50	15.53	0.25	0.37	0.53
Carcass water, %	52.45	50.65	51.57	51.54	0.40	0.24	0.98
Carcass EBW[4], %	53.70	51.78	52.73	52.75	0.44	0.30	0.99
Carcass EBF[5], %	25.24	27.76	26.55	26.46	0.53	0.34	0.98
285 DOF							
Urea space, %	14.90	26.57	12.55	28.93	0.99	0.21	0.118
Carcass lipid, %	33.02	31.79	34.70	30.11	0.56	0.68	0.165
Carcass protein, %	14.39	14.70	14.04	15.05	0.26	0.63	0.160
Carcass water, %	48.25	48.35	47.09	49.52	0.42	0.95	0.193
Carcass EBW[4], %	48.95	49.51	47.69	50.77	0.46	0.78	0.176
Carcass EBF[5], %	31.67	30.56	33.33	28.90	0.55	0.70	0.167
341 DOF							
Urea space, %	26.16	13.58	22.25	16.76	0.94	0.133	0.55
Carcass lipid, %	31.72	38.29	33.87	36.40	0.53	0.014	0.39
Carcass protein, %	14.71	13.32	14.26	13.72	0.25	0.018	0.40
Carcass water, %	48.44	44.13	47.01	45.41	0.40	0.005	0.33
Carcass EBW[4], %	49.58	44.78	48.00	46.18	0.44	0.009	0.37
Carcass EBF[5], %	30.48	36.93	32.59	35.07	0.52	0.013	0.39
Preharvest[6]							
Urea space, %	27.17	23.12	29.23	18.64	0.97	0.65	0.29
Carcass lipid, %	33.36	36.78	33.37	37.60	0.55	0.23	0.184
Carcass protein, %	14.39	13.68	14.40	13.49	0.26	0.25	0.191
Carcass water, %	47.05	44.62	46.88	44.31	0.41	0.132	0.152
Carcass EBW[4], %	48.23	45.64	48.15	45.15	0.45	0.186	0.170
Carcass EBF[5], %	32.13	35.52	32.16	36.28	0.54	0.22	0.181

[1]Blocked by initial BW; LIGHT, HEAVY.
[2]Treatment: F70 = 70% concentrate diet, F85 = 85% concentrate diet.
[3]L = LIGHT, H = HEAVY.
[4]EBW = empty body water.
[5]EBF = empty body fat.

Table 2.6. Carcass merit of purebred Jersey steers fed two different finishing diets.

	BW group[1]		Finishing diet[2]			*P* - value	
Item	LIGHT	HEAVY	F70	F85	SEM	L vs. H[3]	F70 vs. F85
HCW, kg	239.8	269.8	247.2	262.4	4.84	<0.001	0.042
Dressing[4], %	55.9	58.2	56.9	57.2	0.38	<0.001	0.60
Backfat, cm	0.50	0.70	0.61	0.59	0.06	0.044	0.84
KPH, %	2.25	2.80	2.48	2.58	0.16	0.031	0.67
Ribeye area, cm^2	54.0	61.2	54.3	60.9	1.71	0.009	0.015
REA:HCW ratio[5]	1.59	1.60	1.55	1.63	0.07	0.89	0.25
Marbling score[6]	568	661	590	640	17.56	0.002	0.060
Yield grade[7]	2.77	2.97	2.97	2.77	0.14	0.33	0.33
Retail yield[8], %	50.4	49.9	50.0	50.4	0.32	0.30	0.35
NCV[9,10], $/hd	758.65	882.93	781.10	860.49	25.89	0.004	0.046

[1]Blocked by initial BW; LIGHT, HEAVY.
[2]Treatment: F70 = 70% concentrate diet, F85 = 85% concentrate diet.
[3]L = LIGHT, H = HEAVY.
[4]HCW ÷ shrunk final BW.
[5]Ribeye area-to-HCW ratio.
[6]Marbling score scale: 400 = slight, 500 = small, 600 = modest, 700 = moderate, etc.
[7]Yield grade = 2.5 + (2.5 × BF) + (0.0038 × HCW) + (0.2 × KPH) – (0.32 × REA).
[8]Retail yield = 51.34 – (5.78 × BF) – (0.0093 × HCW) – (0.462 × KPH) + (0.740 × REA).
[9]NCV = net carcass value.
[10]NCV = weekly price + grade premium/discount + dairy discount + yield grade premium/discount + HCW discount. Price premiums and discounts observed rom *"National Weekly Carlot Report"* published by USDA.

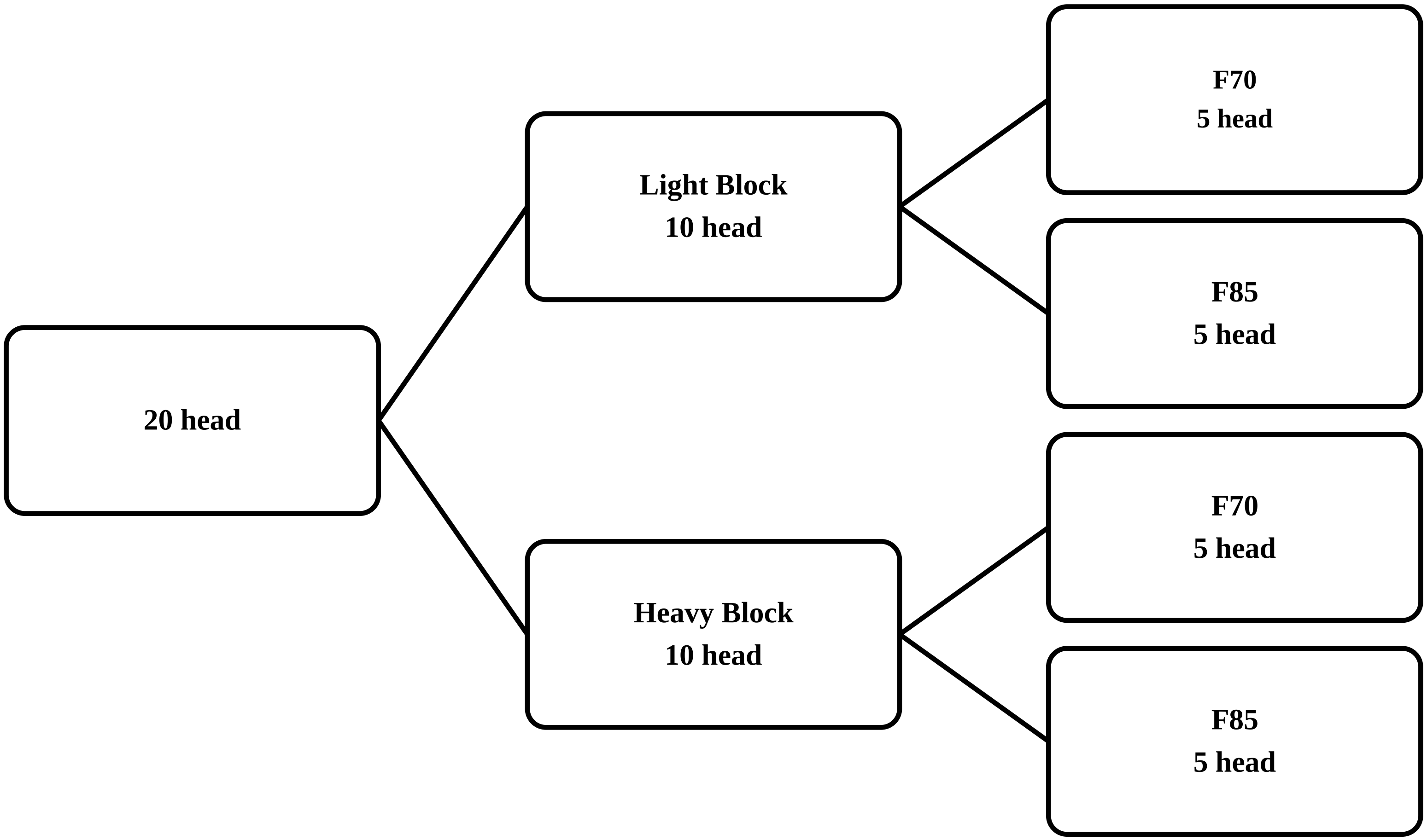
20 head
Light Block
10 head
Heavy Block
10 head
F70
5 head
F85
5 head
F70
5 head
F85
5 head

Figure 2.1. Distribution of purebred Jersey steers between initial BW groupings (block: LIGHT, HEAVY) blocks being fed two different concentrate finishing diets (treatment: F70 = 70% concentrate diet, F85 = 85% concentrate diet).

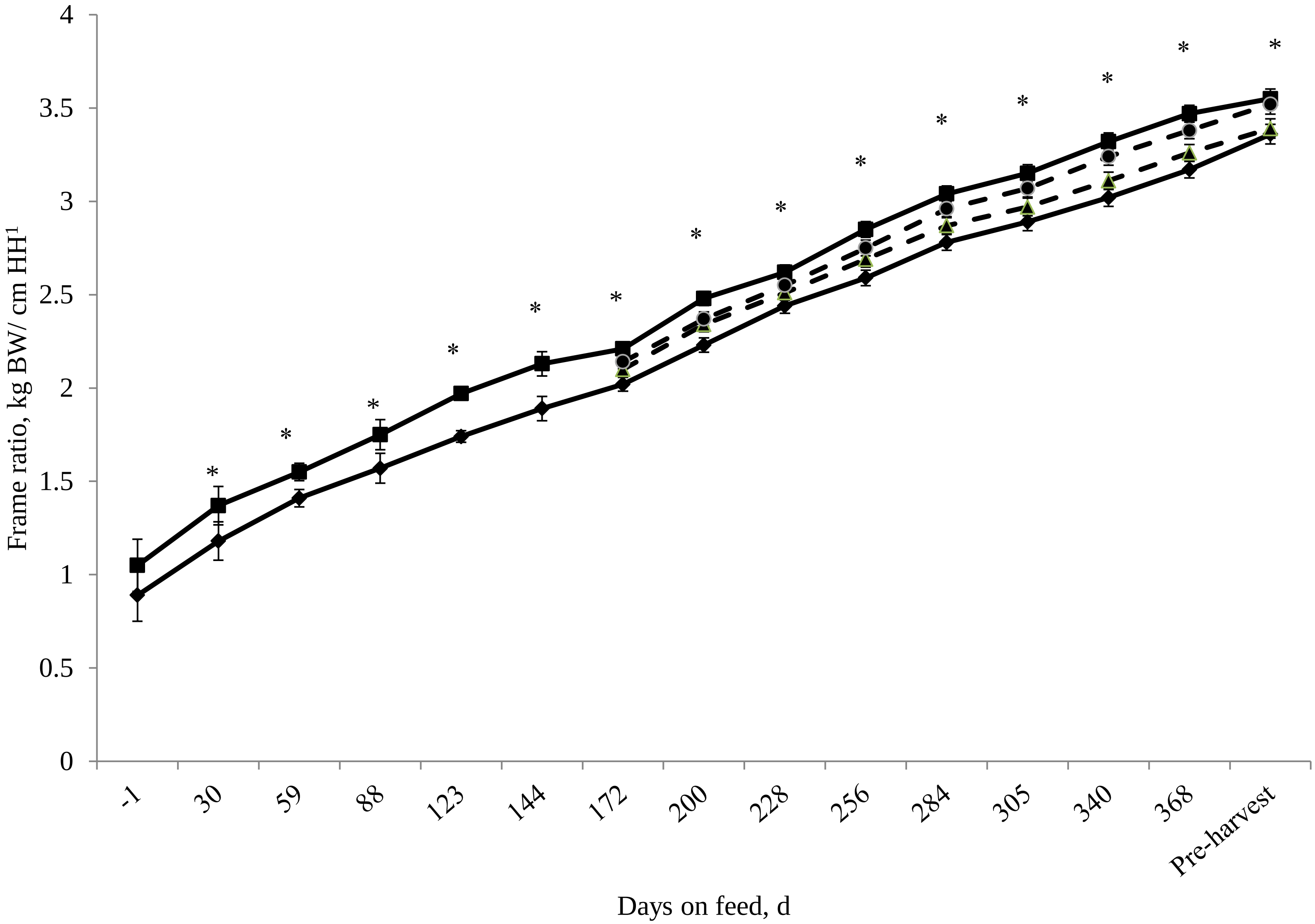
Frame ratio, kg BW/ cm HH1
Days on feed, d
0
0.5
1
1.5
2
2.5
3
3.5
4
-1
30
59
88
123
144
172
200
228
256
284
305
340
368
Pre-harvest

Figure 2.2. Frame ratios of purebred Jersey steers during the growing and finishing phases fed two different finishing concentrate diets. Steers were blocked by initial BW (LIGHT: diamond, solid line; HEAVY: square, solid line) and fed either a moderate concentrate finishing diet (F70 = 70% concentrate diet; triangle, dash line) or a high concentrate finishing diet (F85 = 85% concentrate diet; circle, dashed line). *Differences between LIGHT and HEAVY blocks had a *P*-value of ≤ 0.05. Error bars are representing SEM values. [1]HH = hip height.

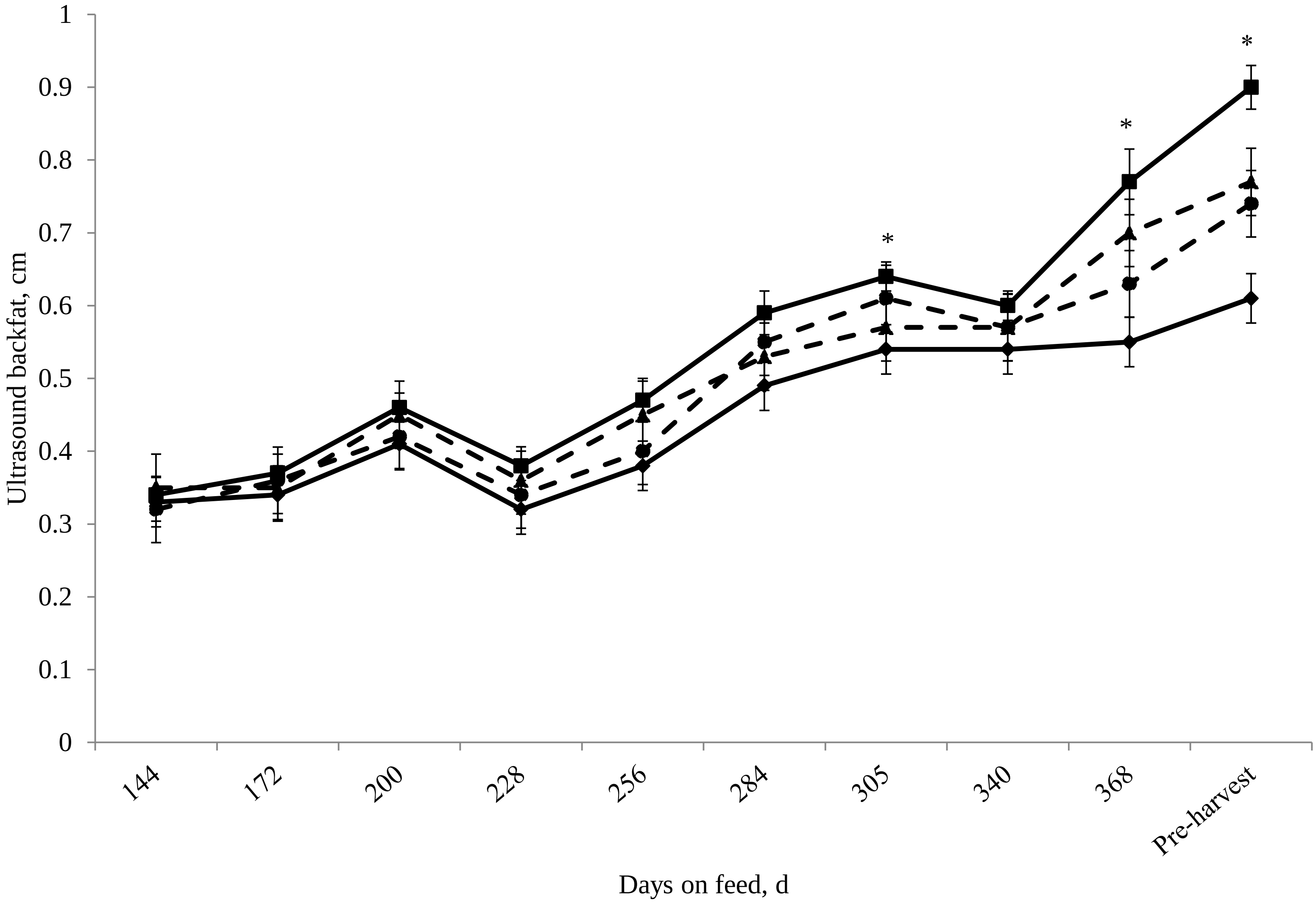
Ultrasound backfat, cm
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
144
172
200
228
256
284
305
340
368
Pre-harvest
*
*
*
Days on feed, d

Figure 2.3. Ultrasound backfat measurements of purebred Jersey steers fed two different finishing concentrate diets. Steers were blocked by initial BW (LIGHT: diamond, solid line; HEAVY: square, solid line) and fed either a moderate concentrate finishing diet (F70 = 70% concentrate diet; triangle, dash line) or a high concentrate finishing diet (F85 = 85% concentrate diet; circle, dashed line). *Differences between LIGHT and HEAVY blocks had a P-value of ≤ 0.05. Error bars are representing SEM values.

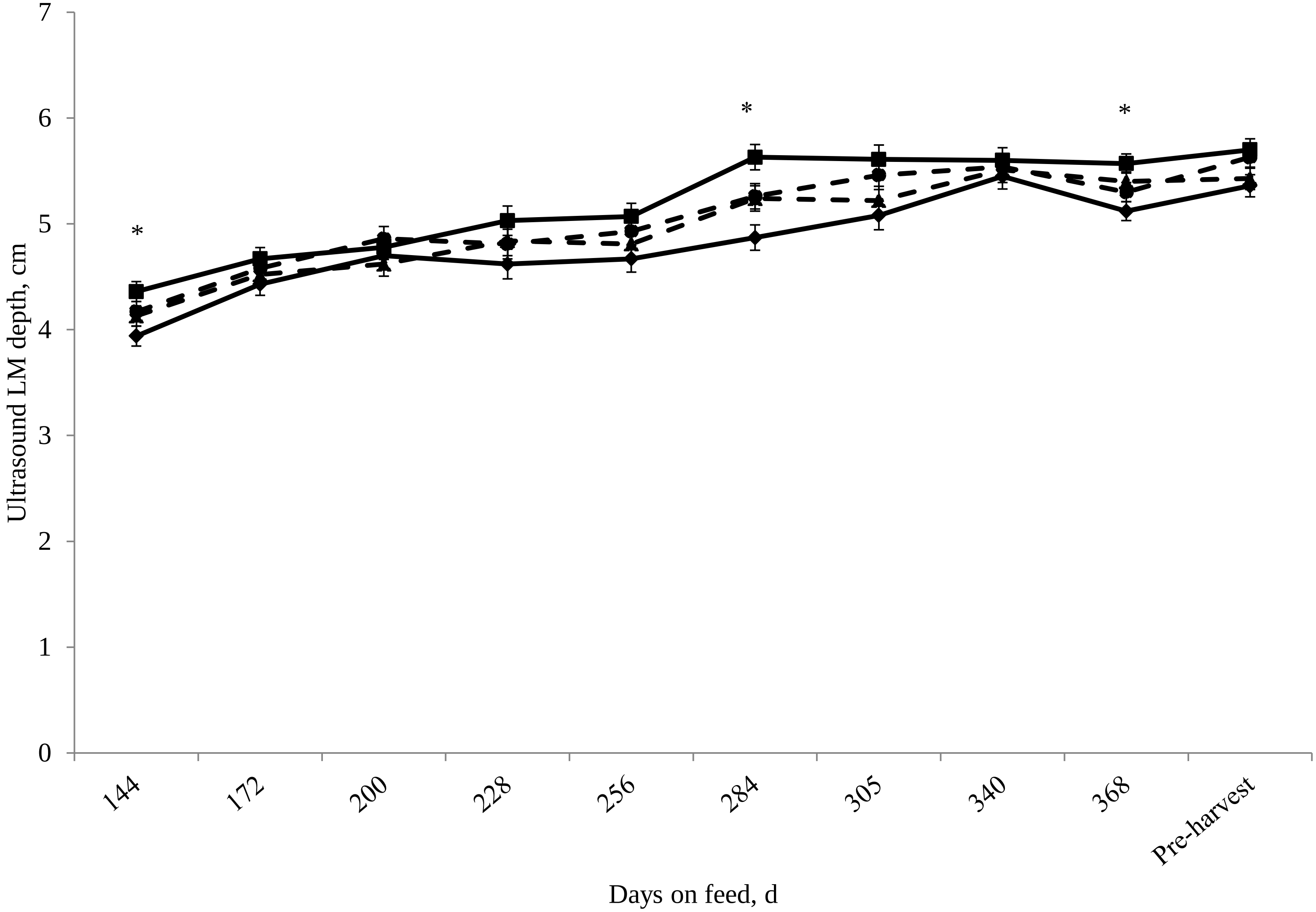
7
6
5
4
3
2
1
0
Ultrasound LM depth, cm
*
*
*
144
172
200
228
256
284
305
340
368
Pre-harvest
Days on feed, d

Figure 2.4. Ultrasound LM depth measurements of purebred Jersey steers fed two different finishing concentrate diets. Steers were blocked by initial BW (LIGHT: diamond, solid line; HEAVY: square, solid line) and fed either a moderate concentrate finishing diet (F70 = 70% concentrate diet; triangle, dash line) or a high concentrate finishing diet (F85 = 85% concentrate diet; circle, dashed line). *Differences between LIGHT and HEAVY blocks had a P-value of ≤ 0.05. Error bars are representing SEM values.

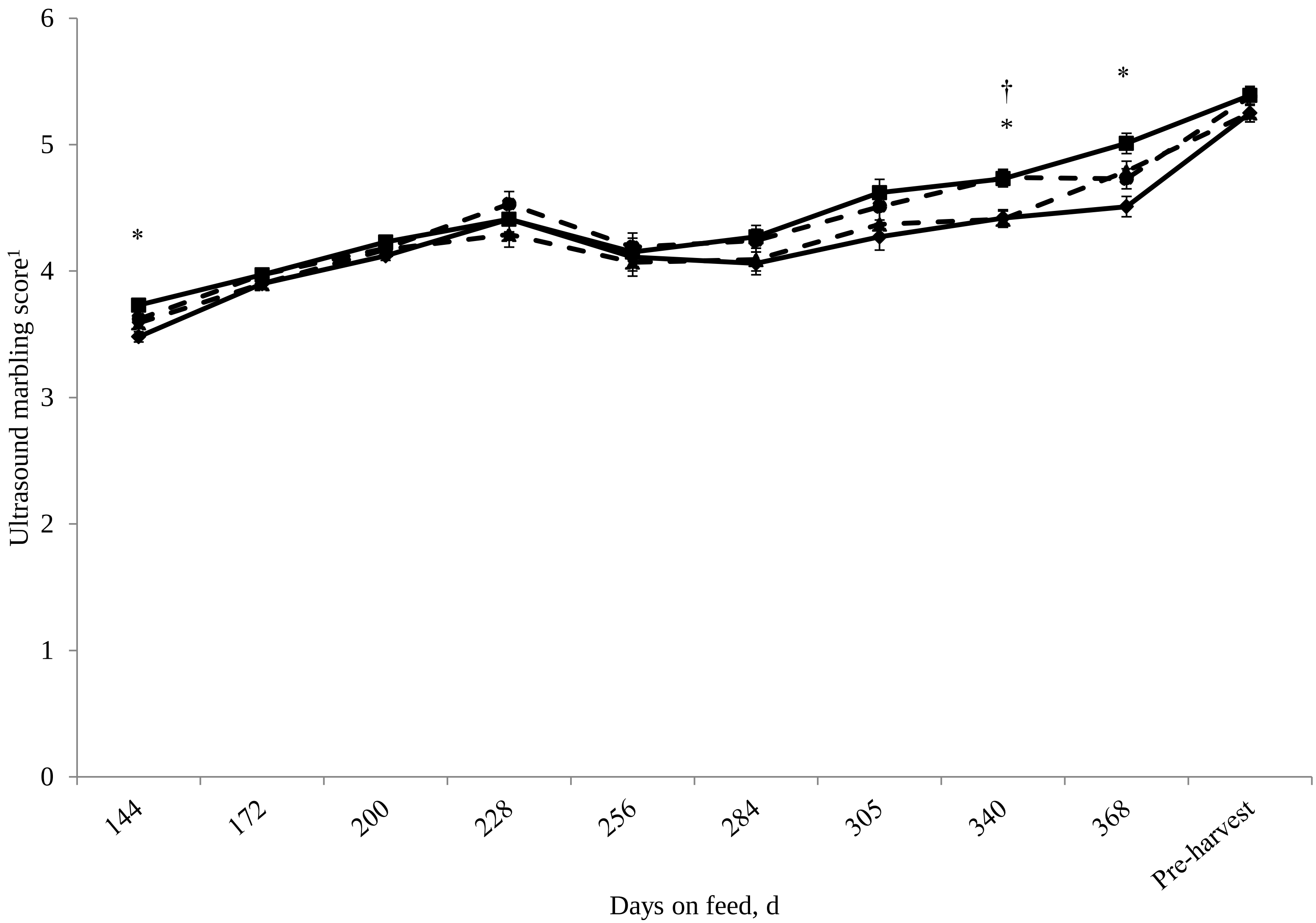
Ultrasound marbling score1
0
1
2
3
4
5
6
*
†
*
*
144
172
200
228
256
284
305
340
368
Pre-harvest
Days on feed, d

Figure 2.5. Ultrasound marbling scores of purebred Jersey steers fed two different finishing concentrate diets. Steers were blocked by initial BW (LIGHT: diamond, solid line; HEAVY: square, solid line) and fed either a moderate concentrate finishing diet (F70 = 70% concentrate diet; triangle, dash line) or a high concentrate finishing diet (F85 = 85% concentrate diet; circle, dashed line). *Differences between LIGHT and HEAVY blocks had a P-value of ≤ 0.05. †Significant difference of P-Value ≤ 0.05 was observed between F70 and F85 finishing diets. Error bars are representing SEM values. [1]Marbling score: 3.0 = standard, 4.0 = select, 5.0 = small, etc.

CHAPTER 3

Meat Quality Attributes of Purebred Jersey Steer Calves Finished on Grain-based Diets at Two Different Energy Levels

G. L. Tschida, C. J. Mueller, V. B. Cannon, and T. Jiang

ABSTRACT: Twenty purebred Jersey steers were used to evaluate lifetime growth and carcass development while finished on different caloric-density diets. Steers were grouped by BW (LIGHT, HEAVY) then randomly assigned to either a 70% (F70) or an 85% (F85) concentrate finishing diet. Within 48 h of harvest, 9-10-11 rib sections and fat samples were removed for fatty acid analysis of muscle tissue, seam, subcutaneous, KPH and omental fat. Fatty acid analysis and sliced shear force (SSF) data were analyzed as a random complete block design for main effects of finishing diet and blocking of initial BW. Taste panel data was tested for normality and compared using a completely randomized design including panelist, sample, session and panelist x session. The F85 meat samples tended to be more ($P < 0.10$) flavorful and juicy versus the F70 samples. Meat samples from the HEAVY steers tended to be more ($P < 0.10$) flavorful, although it received a 60% greater ($P < 0.05$) off-flavor score than F70 meat samples. Omental and KPH fat samples had the lowest MUFA:SFA ratio while muscle, subcutaneous, and seam fat ratios ranged from 1.2 to 1.4. The F70 samples had 33% greater ($P < 0.05$) c-9, t-11CLA compared to F85, while the HEAVY steers were 0.2% greater ($P < 0.05$) in CLA concentrations versus LIGHT steers. The LIGHT steers had greater amounts of Δ-9-desaturase present in subcutaneous fat compared to HEAVY steers although this difference could be due to the different biological states of the steers. Delta-9-desaturase was found in all muscle and fat samples analyzed with the greatest amounts present in subcutaneous tissue ranging from 81.5 to 83.5% of total fatty acids. The enzyme Δ-9-desaturase has been shown to have a strong influence in the amount of oleic and steric acid present in the adipose tissue of beef animals. Oleic acid was present in muscle and fat samples analyzed and ranged from 30.2 to 40.3% of total fatty acids. Steric acid was found in the greatest quantity in internal fat (KPH and omental fat) deposits of the Jersey steers and least abundant in subcutaneous fat. Jersey beef can provide an acceptable and healthy protein source to consumers.

Key Words: Fatty Acids, taste profile, Jersey

INTRODUCTION

Purebred Jersey cattle for beef production has often been overlooked due to their expected poor growth and gain performance (Koch et al., 1976); primarily the result of comingling with other dairy cohorts for beef production. Although Jersey cattle have potential carcass weight and muscling challenges to overcome, the beef industry can be provided with a valuable product that will help reduce the food supply burden that is increasing as the world population continues to grow (FAO, 2009). Jersey cattle have multiple benefits and provide an excellent consumer eating experience. Jersey cattle continually provide a product that grades choice, (Koch et al., 1976; Marshall, 1994; Pitchford et al., 2002; Lehmkuhler and Ramos, 2008; Arnett et al., 2012), and is tender, juicy, and has a satisfying overall flavor (Ramsey et al., 1963; Koch et al., 1976; Purchas and Burton, 1976; Marshall, 1994). Additionally, due to Jersey's softer fat profile, consumers enjoy a unique eating experience that can be compared to Wagyu beef (Pitchford et al., 2002).

A study was conducted at Oregon State University with regards to the growth and development of purebred Jersey steers. The study was developed to provide clarity in growth performance and carcass development of purebred Jersey steers from weaning, though harvest. Steers were fed a common growing ration that provided insight into the steer's early growth and development without the confounding factor of different energy density early in growth. An in depth growth and performance review is presented in Chapter 2 of this thesis. The objective of the meat attribute project was to provide additional consumer information to help determine marketing avenues of purebred Jersey steers, as minimal data is currently published with regards to Jersey beef quality.

MATERIALS AND METHODS

Management of Animals

All procedures within were approved by the Oregon State University Animal Care and Use Committee. (ACUP No. 3572).

Live animal management and feeding is described in detail in chapter 2. Briefly, 20 purebred Jersey steers were blocked into light (**LIGHT**; 77.4 ± 2.48 kg) and heavy (**HEAVY**; 96.7 ± 2.53 kg) groups and finished at Oregon State University's beef cattle feeding facilities (Corvallis, Oregon). Within the BW groups, steers were randomly assigned to either a moderate concentrate finishing diet (**F70**; n = 10 hd) consisting of 70% concentrate and 30% forage, or a high concentrate finishing diet (**F85**; n = 10 hd) consisting of 85% concentrate and 15% forage. Finishing diets were designed to determine if the caloric density had an influence on DOF, along with rate of protein (lean muscle) and fat accretion. Growing and finishing diets were based on NRC (2000) guidelines for beef steers of similar BW. Once steers were projected to reach a choice grade (based on ultrasonography), steers were harvested. Carcass measurements were collected following a 48 h chill period by two trained university personnel. Due to the subjectivity of carcass data collection, the average of the two trained university personnel was used to quantify carcass traits. The left side of each carcass was cut between the 12th and 13th ribs to allow for carcass measurements. Once carcass measurements were taken, 9-10-11 rib sections were then removed from the left side to undergo additional meat quality and taste attribute analysis.

Fatty Acid Analysis

Fat samples were collected prior to carcass washing for fatty acid (**FA**) analysis. Fat samples were obtained from 1) LM backfat, 2) KPH, and 3) omental fat. Due to changes in sampling protocol, KPH and omental fat samples from the first harvest group were not collected. Samples for seam fat and muscle FA analysis were taken at the time of steak fabrication for meat quality attributes. Meat and fat samples were sent to Washington State University (Pullman, Washington) to undergo analysis.

Meat and fat samples were hydrolyzed for 1.5 h at 55°C in 1 *N* KOH in methanol containing C13:0 (internal standard); neutralized, and methylated by H_2SO_4 catalysis for 1.5 h at 55°C (O'Fallon et al., 2007). Methyl esters of FA were then extracted in hexane and quantified by capillary gas chromatography on a SP-2560, 100 m × 0.25 mm × 0.20 μm capillary column (Supelco, Bellefonte, PA) using a Hewlett Packard 3396 Series II integrator and 7673 controller, a flame-ionization detector, and split injection. Initial oven temperature was 140°C, which was held for 5 min and then increased to 240°C at 4°C/min and held for 20 min. Helium was the carrier gas at 0.5 mL/min, and the column head pressure was 2.8 kg/cm. Injector and detector temperatures were 260°C. The split ratio was 30:1. Fatty acids were identified by comparing their retention times to those of methylated FA standards (Nu-Chek Prep Inc., Elysian, MN; Supelco, Bellefonte, PA).

Slice Shear Force

Shear force analysis was conducted using a modification of American Meat Science Association procedures (AMSA, 2009). Two 2.54 cm thick steaks per steer were analyzed for cooking attributes, trained sensory panel, and slice shear force (**SSF**). Steaks were removed from the freezer, weighed, allowed to thaw for a period of 30 h at 2°C, and then re-weighed. Steaks were then cooked utilizing two pre-heated George Forman clam shell grills (model GR35, Salton, Inc., Miramar, FL) to a geometric center temperature of 71°C, as monitored by a Digi- Sense 12 channel scanning thermocouple thermometer (model 9200-00, Cole Palmer, Vernon Hills, IL). Upon reaching the proper internal temperature, steaks were weighed to determine cooking purge. A 1 cm thick × 5 cm long slice was then removed from the lateral end of each steak, parallel to the muscle fibers for SSF measurement (Wheeler et al., 2007). Samples were allowed to cool to room temperature (21°C) with scoring of degree of doneness (1 = very rare to 6 = very well done; 0.5 increments were allowed) determined by trained university personnel (Romans et al., 2001). Meat slices then underwent SSF determination on a Warner-Bratzler Meat Shear (model BFG 1000N; G-R Manufacturing, Manhattan, KS) fitted with a blade designed for SSF. Meat slices were positioned on the blade to shear the muscle fibers at the center of the slice and perpendicular to the muscle fibers along the 5 cm dimension of the slice.

Trained Sensory Panel

Steaks for the trained sensory panel were thawed and cooked as described for SSF. After cooking, any external fat and connective tissue was trimmed off of the remaining sample. The cooked steaks were then cut into 1.0 × 1.0 × 2.54 cm pieces, and served immediately to an 8-member trained sensory panel, with equal numbers of males and females, for evaluation of palatability attributes (AMSA, 2009). Samples were randomly assigned to an individual session, as well as within session, with finishing treatment (F70 or F85) and BW group (LIGHT or HEAVY) stratified across all panel sessions. Samples were served to panelists in individual booths per session under fluorescent lighting (400-800 lx; measured by a Traceable Dual-Range Light Meter, Thermo Fisher Scientific, Waltham, MA). Panelist utilized a 10 cm unstructured line labeled at each end (Stone and Sidel, 1985) to evaluate each sample on beef aroma (0 = bland to 10 = intense beef aroma), off-aroma (0 = none detected to 10 = pronounced), initial and sustained tenderness (0 = tough to 10 = tender), juiciness (0 = dry to 10 = juicy), flavor intensity (0 = bland and 10 = intense), off-flavor (0 = none detectable to 10 = pronounced), and overall acceptability (0 = low to 10 = high). A ruler was then used to quantify panelist scores. Each panelist was supplied with unsalted crackers to cleanse the palate, distilled water to rinse, and a cup for expectoration between samples.

Meat Quality and Fatty Acids. A complete listing and a more in depth review of fatty acids has been published by Washington State University by Jiang et al. (2013). However, due to some deficiencies in the data published, we have included a review of the meat quality attributes and focused on the fatty acid profiles and ratios of those fatty acids that are important for human health as they were not published by Jiang et al. (2013).

Statistical Analysis. Fatty acid analysis and SSF data were analyzed as a randomized complete block design for main effects of finishing diet and blocking factor of BW using the GLM procedure of SAS (version 9.1, SAS Institute, Inc., Cary, NC). Individual steer was the experimental unit, and steer within BW group x finishing treatment was the error term. Block and treatment means were separated using least square means procedures and were considered significant at the $P < 0.05$ level. Tendencies were identified for alpha-levels between 0.05 and 0.10. Normality of the taste panel data was confirmed by univariate analysis (PROC UNIVARIATE). The consistency of panelist performance across session was tested by a completely randomized design with model including panelist, sample, session, and panelist x session. Residual error was used as the error term.

RESULTS AND DISCUSSION

An in-depth review of the meat quality attributes of Jersey steers has been published by Washington State University by Jiang et al. (2012).

In the previous chapter, it was determined that Jersey steers can reach the benchmarks set forth by the beef industry in terms of a quality beef product. Steers that were fed the moderate concentrate diet were able to reach the low choice quality grade with a marbling score of 568, putting it in the upper end of the low choice grade while the steers consuming the high energy dense diet were on the upper end of the choice grade.

This would indicate that consumers should have a favorable eating experience. Cole et al. (1964) reported that Jersey beef can provide a quality eating experience that is equal or better than that provided by Angus and Hereford beef. Therefore, sensory attributes were analyzed through a blind taste panel as well as tenderness analyzed via mechanical mechanism for SSF. The results from the taste panel would indicate that Jersey steers would provide the consumer with an acceptable eating experience (Table 1.1). Although there were no significant ($P > 0.25$) differences in initial tenderness and sustained tenderness attributed to the dietary finishing treatment, it should be noted F85 meat samples had a tendency ($P = 0.092$) for more pronounced flavor over F70 samples. Additionally, the F85 steers tended ($P = 0.094$) to provide a more juicy eating experience as compared to the F70 steers. This study was limited in numbers and if conducted on a larger scale, steers that consume a more energy dense diet may provide a consumer experience with greater favorability. Meat samples from the HEAVY steers tended ($P = 0.084$) to have a greater flavor score than their LIGHT counterparts, although the difference is minimal. From the sensory attribute study, one area of concern would be that the HEAVY steers had greater ($P = 0.031$) off-flavor. It should be noted that the score was below 1, and is of minimal concern regarding consumer preferences.

As consumers become ever more conscious of their health, many are viewing their options as it relates to protein for their diets, whether it comes from animal or plant sources. Jersey beef has several characteristics that can provide the consumer with greater health benefits. Beef influenced by Jersey genetics could potentially provide greater concentrations of MUFAs as compared to other breeds of cattle. This fact should be noted as human health research is discovering that MUFAs are more beneficial than once thought and have a significant impact with regards to SFA, as they are known for lowering cholesterol levels (Whetsell, et al., 2003; Siebert et al., 1999; Nydahl et al., 1999). Jersey beef in this study indicated no differences ($P > 0.20$) between BW groups or finishing diet treatments for MUFA:SFA ratio (Table 3.2). Similar ratios were observed for muscle tissue, subcutaneous fat, and seam fat (Table 3.2). Conversely, the ratio of MUFA:SFA was relatively low in omental fat of the steers. Additionally, Chin et al. (1992) stated that beef can provide a good source of conjugated linoleic acid. This is of importance due to the mixture of octadecadienoic acids which have been shown to have a positive benefit on human health due to their anti-carcinogenic properties (Chin et al., 1992; Lin et al., 1995). Steers consuming the F70 diet had 50% greater ($P = 0.025$) CLA present in the muscle samples as compared to their F85 counterparts, although both levels present were a small percentage of the overall fatty acid profile (Table 3.2). Additionally, muscle tissue provides greater concentrations of CLA in the cis-9, trans-11 configuration than would be available in the fat tissue. The F70 meat samples had 33% more ($P = 0.024$) CLA present in subcutaneous fat when steers consumed the moderate energy dense diet, which may be attributed to the amount of forage available in the ration. In a review of fatty acid profiles comparing grass-fed to grain-fed beef, it was noted that the cattle fed on the grass had a greater rumen pH allowing a more favorable environment for the bacteria responsible for synthesis of CLA, thereby allowing more to be available in the final product (Daley et al., 2010). It should be noted that the HEAVY steers had greater ($P = 0.014$) amounts of CLA present in subcutaneous fat than did the LIGHT steers.

Palmitic, steric, and oleic acids are the three main fatty acids that consumers can obtain when eating beef; and they combine for 80% of fatty acids present in beef (Whetsell et al., 2003). Outside of beef consumption, consumers can consume oleic acid from various sources and is found in high amounts in plant oils (Whetsell et al., 2003). Oleic acid accounts for 33% of the fatty acids present in beef (Whetsell et al., 2003). The concentration level of oleic acid in ruminant animals is hydrogenated primarily to steric acid by the ruminal microorganisms which is contrary to other species in that the level of oleic acid is determined by their nutritional influences (Smith et al., 2006). Steric acid has been shown to have no known effect on human health (Grundy, 1994) and accounts for approximately 18% of fatty acid in beef (Whetsell et al., 2003). In our study, no differences ($P > 0.17$) were observed between BW groups or finishing diet treatments for oleic acid. High concentrations (ranged from 30.2 to 40.3% of fatty acid present in respective sample) of oleic acid were found in analyzed muscle and fat samples (Table 3.3). Palmitic acid ranged from 21.9 to 25.6% in respective samples, which was similar to those reported by Whetsell et al. (2003). There were no differences ($P > 0.46$) in palmitic acid concentration for muscle, seam, KPH, or omental fat between BW groups. The HEAVY steers tended to have less ($P = 0.098$) palmitic acid present in subcutaneous fat than did their LIGHT counterparts, although it was minimal (24.3 vs. 25.6% of total fatty acids, respectively). There were no differences ($P > 0.31$) in palmitic acid concentration for finishing diet within any fat sampling locations. There were no overall differences (*P* > 0.33) in steric acid concentrations present in muscle or fat locations between finishing treatments (Table 3.3). Steric acid concentrations were greatest in KPH and omental fat tissues, and least in (8.3 and 8.8 % of total fatty acids, LIGHT vs. HEAVY, respectively) subcutaneous fat (Table 3.3). There was a difference (*P* = 0.030) in steric acid concentrations between LIGHT and HEAVY steers when analyzing the subcutaneous fat tissue, with the LIGHT steers having 7.9% steric acid present while the HEAVY steers had 9.2% steric acid.

Delta-9-desaturase has been shown to have a profound impact on certain fatty acids. Delta-9-desaturase concentration will be a determining factor in the concentration of oleic acid in beef adipose tissue as it is responsible for the addition of a double bond to steric acid to complete the conversion to oleic acid (Smith et al., 2006; Whetsell et al., 2003). In our study, Δ-9-desaturase was present in the greatest amount in subcutaneous fat and lowest in internal fat (KPH and omental) (Table 3.2). The LIGHT steers had greater (*P* = 0.027) concentrations of Δ-9-desaturase available for conversion than their HEAVY counterparts in subcutaneous fat, though biologically they were relatively similar. No differences (*P* > 0.35) were observed for Δ-9-desaturase between LIGHT and HEAVY or F70 and F85 muscle and fat samples.

This study confirms that Jersey beef can provide an acceptable and healthy product to consumers for an enjoyable eating experience. The steers consuming the more energy dense diet provided a more flavorful and juicy product than F70 steers, though this could be attributed to the fact that the F85 steers had an 8.5% higher marbling score. Although there was a difference for off-flavor between LIGHT and HEAVY steers, the difference was minimal and a study with greater numbers will need to be conducted in order to determine if there is any concern regarding consumer acceptability.

More investigation should be conducted to help determine if different management schemes could influence fatty acid composition within Jersey beef, as it has been noted in several studies that have investigated differences between forage-fed and grain-fed diets. Purebred Jersey steers provide a fatty acid profile that is similar to traditional beef bred animals. The meat quality and taste attributes reported within, help support that Jersey beef can provide an acceptable eating experience for the consumer.

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Table 3.1. Sensory attributes and slice shear force values of purebred Jersey steer fed two different finishing diets.[1]

	BW group[2]		Finishing diet[3]			*P* - value	
Item	LIGHT	HEAVY	F70	F85	SEM	L vs. H[4]	F70 vs. F85
Initial tenderness	6.7	6.2	6.2	6.7	0.27	0.19	0.25
Aroma	5.3	5.2	5.2	5.3	0.14	0.81	0.64
Off-aroma	0.7	0.9	0.7	0.9	0.09	0.32	0.26
Flavor	5.3	5.6	5.3	5.6	0.11	0.084	0.092
Off-flavor	0.5	0.8	0.6	0.7	0.08	0.031	0.75
Juiciness	5.6	5.7	5.4	5.9	0.23	0.91	0.094
Sustained tenderness	6.2	5.7	5.8	6.1	0.22	0.14	0.38
Overall acceptability	5.7	5.5	5.5	5.7	0.17	0.37	0.49
SSF[5], kg	17.20	18.90	17.71	18.40	1.02	0.23	0.62

[1]Recreated from Jiang et al (2013).
[2]Blocked by initial BW; LIGHT, HEAVY.
[3]Treatment: F70 = 70% concentrate diet, F85 = 85% concentrate diet.
[4]L = LIGHT, H = HEAVY.
[5]SSF = slice shear force.

Table 3.2. Total fat and fatty acid ratios of muscle and fat deposits from purebred Jersey steers fed two different finishing diets.

	BW group[1]		Finishing diet[2]			*P* - value	
Item[3]	LIGHT	HEAVY	F70	F85	SEM	L vs. H[4]	F70 vs. F85
Fat total							
Muscle tissue	5.7	6.8	6.7	5.8	0.69	0.29	0.38
Subcutaneous fat	80.8	84.6	83.0	82.4	1.45	0.082	0.78
Seam fat	84.8	84.9	84.6	85.1	1.51	0.99	0.82
KPH fat	92.2	91.0	89.5	93.7	1.27	0.50	0.035
Omental fat	88.6	86.5	87.5	87.6	1.67	0.47	0.98
MUFA:SFA ratio							
Muscle tissue	1.2	1.2	1.2	1.2	0.03	0.39	0.36
Subcutaneous fat	1.4	1.4	1.4	1.4	0.04	0.77	0.89
Seam fat	1.2	1.2	1.2	1.2	0.05	0.61	0.87
KPH fat	0.7	0.7	0.7	0.7	0.04	0.20	0.27
Omental fat	0.8	0.8	0.8	0.8	0.06	0.99	0.47
PUFA:SFA ratio							
Muscle tissue	0.13	0.10	0.12	0.12	0.01	0.074	0.90
Subcutaneous fat	0.07	0.08	0.08	0.07	0.003	0.12	0.067
Seam fat	0.08	0.08	0.08	0.07	0.004	0.91	0.21
KPH fat	0.04	0.04	0.04	0.04	0.003	0.58	0.71
Omental fat	0.05	0.05	0.05	0.05	0.003	0.98	0.20
Δ-9 desaturase							
Muscle tissue	77.3	78.2	77.7	77.9	0.50	0.35	0.88
Subcutaneous fat	83.5	81.5	82.8	82.1	0.61	0.027	0.39
Seam fat	76.6	76.8	76.5	76.8	0.94	0.92	0.85
KPH fat	57.2	59.2	56.7	59.6	2.09	0.52	0.36
Omental fat	60.6	59.7	61.6	58.7	2.22	0.81	0.46
C-9, T-11 CLA; C18:2c9, t11							
Muscle tissue	0.25	0.28	0.30	0.23	0.02	0.31	0.025
Subcutaneous fat	0.64	0.76	0.75	0.64	0.04	0.014	0.024
Seam fat	0.67	0.65	0.70	0.62	0.04	0.80	0.24
KPH fat	0.20	0.22	0.24	0.19	0.02	0.51	0.033
Omental fat	0.20	0.20	0.24	0.16	0.02	0.93	0.017

[1]Blocked by initial BW; LIGHT, HEAVY.
[2]Treatment: F70 = 70% concentrate diet, F85 = 85% concentrate diet.
[3]Values are expressed % of total fatty acids.

Table 3.3. Concentration of Palmitic, Steric, and Oleic fatty acids in muscle and fat deposits of purebred Jersey steers fed two different finishing diets.[1]

	BW group[1]		Finishing diet[2]			*P* - value	
Item[3]	LIGHT	HEAVY	F70	F85	SEM	L vs. H	F70 vs. F85
Palmitic acid; C16:0							
Muscle tissue	24.8	25.3	24.8	25.4	0.40	0.46	0.31
Subcutaneous fat	25.6	24.3	25.1	24.8	0.52	0.098	0.71
Seam fat	24.3	23.8	23.8	24.3	0.49	0.49	0.52
KPH fat	24.9	24.4	24.8	24.6	0.59	0.63	0.80
Omental fat	22.3	22.1	21.9	22.5	0.56	0.78	0.56
Steric acid; C18:0							
Muscle tissue	11.6	11.2	11.6	11.2	0.42	0.60	0.60
Subcutaneous fat	7.9	9.2	8.3	8.8	0.41	0.030	0.33
Seam fat	11.7	11.9	11.9	11.7	0.48	0.85	0.87
KPH fat	22.9	22.1	23.2	21.9	1.20	0.69	0.51
Omental fat	22.0	22.7	21.3	23.4	1.32	0.14	0.37
Oleic acid; C18:1n9							
Muscle tissue	39.4	40.3	40.2	39.5	0.48	0.17	0.24
Subcutaneous fat	39.8	40.2	39.8	40.2	0.81	0.74	0.78
Seam fat	38.5	39.2	38.8	39.0	0.90	0.55	0.88
KPH fat	30.2	32.2	30.2	32.2	0.93	0.22	0.21
Omental fat	33.5	33.6	33.8	33.3	1.12	0.95	0.80

[1]Blocked by initial BW; LIGHT, HEAVY.
[2]Treatment: F70 = 70% concentrate diet, F85 = 85% concentrate diet.
[3]Values are expressed % of total fatty acids.

CHAPTER 4

CONCLUSION

Previous research has shown purebred Jersey steers have reduced growth and performance, especially when compared to beef breeds. This has created a restricted market for the purebred Jersey producer to overcome, as they receive minimal compensation for their male "end products". There is a lack of demand from the cattle feeding industry to finish Jersey calves; while veal markets are small and regionalized throughout the United States. Additionally, as production agriculture responds to public animal welfare concerns, veal markets are diminishing thereby creating a more saturated market. Jersey diary producers have been left with no other choice other than euthanize the male progeny as their last resort, especially since most producers believe it is more humane and welfare friendly than to have the calves enter the veal markets.

The studies presented help clarify the growth patterns of purebred Jersey steers from weaning to harvest in hopes of determining optimal growth characteristics with carcass merit to improve fed marketing potential. It was determined that purebred Jersey steers are slower growing and have potential performance obstacles (reduced feed efficiency, lighter live and carcass weights) that are going to limit the amount of interest from beef cattle feeders. Steers in the HEAVY block were 8% heavier and consumed 12% more DMI than LIGHT steers; although there was no difference between LIGHT and HEAVY steers in ADG and G:F. Steers consuming the 85% concentrate diet (F85) had 11% greater ADG and were 9% more efficient in G:F finishing the trial at 6% heavier over the steers consuming the 70% concentrate diet (F70).

Purebred Jersey steers can produce a highly marbled meat product (low choice quality grade or better) at light body weights, therefore cattle feeders should concentrate on increasing harvest weights to improve yield grades and minimize carcass discounts. Cattle feeders must be cognizant of the upper threshold in terms of yield grade and back fat and determine which will provide the least discounts to the producer. Steers within the HEAVY block had 12.5% greater HCW with a 13% larger REA and 16% greater marbling score over the LIGHT steers. Consequently, HEAVY steers were $124.28/hd more profitable in carcass value than the LIGHT steers. The F85 steers had 6% greater HCW with a 12% larger REA that graded 8% greater in marbling over the LIGHT steers. Therefore, the F85 steers were $79.39/hd more profitable in carcass value than the F70 steers. Based on taste panel results, meat from Purebred Jersey steers can provide the consumer a highly valued eating experience. Additionally, purebred Jersey steers can help provide the consumer with a high quality protein source that will provide the healthy advantages of reduced omega 6:3 ratios, increased conjugated linoleic acid concentrations, and MUFA:SFA ratios in line with a healthier product.

Future research in purebred Jersey steers needs to be conducted to look at potential ways that can aid in creating more profitability and subsequent interest from beef cattle feeders. The beef industry has several tools that should be investigated. Taking advantage of growth and performance from anabolic steroids or the use of synthetic β-adrenergic agonists to help increase overall lean muscle tissue, could provide the purebred Jersey steers the needed growth, performance and lean tissue mass that is needed to make them more marketable and potentially profitable.

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Appendix

A.1. Common Abbreviations and Terminology Definitions:

(ADF) Acid Detergent Fiber: Portion of a forage sample that is insoluble when boiled in an acid detergent solution, or the structural components of the cell wall minus hemicellulose (cellulose, lignin, silica and cutin). ADF is important in animal nutrition because it is negatively correlated to digestibility.

(ADG) Average Daily Gain: Measurement of the average daily body weight change over a specified period of time of an animal on a feed test.

(AI) Artificial Insemination: The technique of placing semen from the male into the reproductive tract of the female by means other than natural service.

(AMSA) American Meat Science Association: Association that fosters community and professional development among individuals who create and apply science to efficiently provide safe and high quality meat (defined as red meat (beef, pork, and lamb), poultry, fish/seafood and meat from other managed species).

(β-AA) β-Adrenergic Agonists: A feed additive that improves the cattle's natural ability to convert feed into more lean beef.

(BIF) Beef Improvement Federation: Organization dedicated to advancing and coordinating all segments of the beef industry by connecting science and industry to improve beef cattle genetics.

(BW) Body Weight: The live weight of an animal’s body.

(CLA) Conjugated Linoleic Acid: A naturally occurring trans-fat in the human diet; is a family of at least 28 isomers of linoleic acid found mostly in the meat and dairy products derived from ruminants. CLA can be either cis- or trans- fats and the double bonds of CLAs are conjugated and separated by a single bond between them.

(Cx) Charolais Cross Cattle: Cattle that are at least 50% comprised of Charolais genetics.

(d) Day(s): a unit of time measurement; consists of 24 hours.

(DM) Dry Matter: Feed after water (moisture) has been removed (100% dry).

(DMI) Dry Matter Intake: Amount of feed intake by the animal on a dry matter basis.

A.1. (Continued)

(DNA) Deoxyribonucleic Acid: A molecule that encodes the genetic instructions used in the development and functioning of all known living organisms.

(DOF) Days on Feed: Number of days an animal has been receiving feed.

(EBF) Empty Body Fat: Estimation of the amount of fat that would remain once the animal is harvested.

(EBW) Empty Body Water: Estimation of the amount of water that would remain once the animal is harvested.

(F70) Finishing Diet 70: A finishing diet comprised of 70% concentrate and 30% roughage fed to the purebred Jersey steers in the current study.

(F85) Finishing Diet 85: A finishing diet comprised of 85% concentrate and 15% roughage fed to the purebred Jersey steers in the current study.

(FA) Fatty Acid: A carboxylic acid with a long aliphatic tail, which is either saturated or unsaturated.

(FAO) The Food and Agriculture Organization of the United Nations: A specialized agency of the United Nations that leads the international efforts to defeat hunger.

(G:F) Gain-To-Feed: Amount of gain received (output) compared to one pound of feed (input).

(G1) Growing Diet 1: The initial growing diet that was fed to purebred Jersey steers in the current study.

(G2) Growing Diet 2: The second growing diet that was fed to purebred Jersey steers in the current study. Was reformulated from the G1 diet to better match the growth and nutritional needs of the purebred Jersey steers.

(h) Hour(s): A measurement of time within the day.

(HCW) Hot Carcass Weight: The weight of the carcass just prior to chilling.

(hd) Head: A measurement of number of animals.

A.1. (Continued)

(HEAVY) Heavy Block: Purebred Jersey steers that were included within the heavy block of the current study.

(HH) Hip Height: A measurement of height taken at the animals hip bones.

(IV) Intravenous: Within the vein. An intravenous injection is made into a vein.

(Jx) Jersey Cross Cattle: Cattle that are at least 50% comprised of Jersey genetics.

(KPH) Kindey, Pelvic, Heart Fat: The internal carcass fat associated with the kidney, pelvic cavity, and heart. It is expressed as a percentage of chilled carcass weight. The weight of the kidneys is included in the estimate of kidney fat.

(LIGHT) Light Block: Purebred Jersey steers that were included within the light block of the current study.

(LM) Longissimus Muscle: The muscle lateral to the semispinalis. It is the longest subdivision of the sacrospinalis that extends forward into the transverse processes of the posterior cervical vertebrae.

(MARC) Meat Animal Research Center: Research center where live animal studies were conducted in Clay Center, Nebraska.

(Mcal) Megacalorie: A measurement of energy provided by the feedstuff.

(MUFA) Monounsaturated Fatty Acid: Fatty acids that have one double bond in the fatty acid chain and all of the remainder of the carbon atoms in the chain are single-bonded. The molecules contain less than the maximum amount of hydrogen.

(NBQA) National Beef Quality Audit: An audit that is conducted to determine the qualities of beef carcasses being harvested and then compared to previous data to determine improvement of the beef industry.

(NCBA) National Cattlemen's Beef Association: Association of cattlemen that promotes and protects the livelihood of the beef industry.

(NDF) Neutral Detergent Fiber: Portion of a forage sample that is insoluble when boiled in a neutral detergent solution or the structural components of the cell wall (hemicellulose, cellulose, lignin, silica and cutin). NDF is important in animal nutrition because it is negatively correlated to dry matter intake.

A.1. (Continued)

(NEg) Net Energy Gain: The ability of the feed to meet the energy requirements for gain.

(NRC) National Research Council: Provides publications on nutrient requirements of different species.

(PUFA) Polyunsaturated Fatty Acid: Triglycerides in which the hydrocarbon tails possess more than a single carbon-carbon double bond. The molecules contain less than the maximum amount of hydrogen.

(PUN) Plasma Urea Nitrogen: Amount of urea nitrogen that is circulating through the animal's plasma.

(PYG) Preliminary Yield Grade: The baseline prior to adjustments (including HCW, REA, fat thickness, and estimated KPH) being taken into account predicting the animals differences in cutability- the boneless, fat-trimmed retail cuts from the round, loin, rib, and chuck.

(REA) Ribeye Area: Area in square centimeters of the longissimus muscle measured at the 12th rib interface on the beef forequarter.

(REA:HCW) Ribeye Area-To-Hot Carcass Weight Ratio: Relation of ribeye area in perspective to a pound of hot carcass weight.

(RGR) Relative Growth Rate: The rate (%) by which growth will occur.

(SFA) Saturated Fatty Acid: A fat consists of triglycerides containing only saturated fatty acids by having no double bonds between the individual carbon atoms of the fatty acid chain.

(SSF) Slice Shear Force: An estimation of the tenderness of the meat.

(US) Urea Space: Amount of the body that is available for uptake of urea into the body's tissues.

(USDA) United States Department of Agriculture: Part of the government that is responsible for developing and overseeing the farming, agriculture and food supply for the entire country.

(wk) Week(s): A measurement of time; comprised of 7 days.