TEXAS TECH UNIVERSITY
Department *of* Animal
& Food Sciences

White Paper:

Dairy-Beef Production Systems for Sustainable Agriculture

Dale R. Woerner and Blake A. Foraker,
Department of Animal and Food Sciences,
Texas Tech University, Lubbock, TX

Overview

Beef production has been heavily criticized for production inefficiencies and adverse environmental effects; therefore, if the sustainability of beef production is not improved, it will become a nonviable option of food production. Approximately 20% (5.5 million head) of all fed beef animals in the U.S. result from dairy offspring (fed Holstein steers and heifers). Yet, a dairy farmer's primary objective is not beef production – it is to breed cows and create a milking cycle upon calving. Assuming a male to female calf ratio of 1:1, only 30% of the female calves replace older cows removed from the herd each year. The remainder of dairy calves, often deemed a by-product, are terminally bound for the beef supply chain. In comparison to producing beef from conventional beef and F1 beef x dairy animals, producing beef with purebred dairy cattle is not efficient. Once at the feedlot, purebred dairy offspring require significantly more resources - thousands of gallons of water, tons of feed, and an additional 150 days on feed. They are more susceptible to morbidity and mortality, and due to a lack of economic value, dairy calf euthanasia is often hidden from public perception. Furthermore, purebred dairy carcasses produce some 30% less beef per animal and have more significant by-product condemnations (organ meats and offal items). This equates to a far less efficient and less environmentally friendly means of producing beef. Rather than continuing the inefficiency of breeding all dairy cows to dairy bulls, the beef and dairy industries need to work together to produce more efficient, higher producing beef animals by breeding dairy cows that are not producing replacement females to beef type bulls. ***The lowest hanging fruit for producing high-quality beef more efficiently in the U.S. is to implement a widespread, systems-based approach of crossbreeding dairy cows to complementary beef sires to advance sustainability by reducing the environmental impact and improving profitability.***

Integration of beef genetics into the dairy system may recuperate economic and environmental inefficiency costs currently associated with beef production from purebred dairy animals. Currently, there are no market signals to incentivize dairy operators to produce higher quality beef animals in a more efficient manner, despite their significant representation in the beef industry (20%). Some data suggest that dairy breeding may positively influence the eating quality of beef because of added marbling and increased tenderness. Furthermore, given the intensive requirements of feeding the purebred dairy animal, the carbon footprint, including greenhouse gas emissions (CH_4 and CO_2), can be drastically improved by implementing crossbreeding practices. Yet, scientific data to determine the corresponding value of these influences in beef x dairy crossbred animals do not exist. In addition, dairy farmers are seemingly hesitant to implement this type of breeding program as there are no published data regarding how these scenarios would impact the performance (lactation), longevity, and condition of the milk-producing cows, which is perhaps of greatest interest to the dairy farmer. Dairy farms contribute significantly to U.S. agricultural production and help to sustain rural communities nationwide. However, due to very low current milk prices, the sustainability of U.S. dairy farms is in question, and adding value to calves destined for beef production may help to perpetuate the family-owned dairy farm.

The concept of breeding dairy cows to beef sires, now being referred as "beef on dairy", is not completely novel, as there are some progressive operations utilizing this approach; however, there has not been widespread implementation for this concept (2% of total fed beef cattle). Dairy producers historically were hesitant to implement this crossbreed system because: 1) producing beef is not their primary objective; 2) genetic selection criteria for volume and quality of milk production is not correlated with desirable traits for beef production; 3) fertility is the main concern of dairy producers for producing

milk, and there is not published data on fertility performance in outcrossing scenarios; 4) dairy influenced offspring are heavily discounted by the feeding and packing industry; 5) intensive management and increased cost are required to produce viable calves for the feeding sector. As more research is conducted and more of these questions are answered, it is expected that more dairy farms will engage in the beef on dairy concept. Producing crossbred cattle versus producing purebred dairy cattle for the purpose of beef production will result in drastic improvements in efficiency and contribute greatly to the beef and dairy industry's sustainability.

Impact of the Beef on Dairy Concept on Cow, Feedlot, and Carcass Performance

Widespread implementation of Beef on Dairy only occurs if all segments of the industry have confidence in its effect on measures related to profitability. Irish studies in the 1980s previously reported that breed of calf sire, whether dairy or beef, had no adverse effect on milk production and minimal effect on reproductive traits in dairy cows (Badi et al., 1985; O'Ferrall and Ryan, 1990). Still, the only U.S. study to report on this effect (Scanavez and Mendonça, 2018) concluded that sire breed affected gestation time and produced mixed results on milk yield, depending on the breed of the dam (Holstein versus crossbred). Feedlot growth and carcass performance of conventional beef steers and Holstein steers has been extensively studied, particularly related to the use of beta-adrenergic agonists (Beckett et al., 2009; Arp et al., 2014; Howard et al., 2014). However, no recently published study in the U.S. has evaluated feedlot growth performance and carcass characteristics of beef on dairy calves. This observational study aimed to provide an understanding of performance in dairy cows bred to beef sires and feedlot and carcass performance of beef on dairy calves.

An observational study funded by Cargill, Inc. through their BeefUp Sustainability initiative aimed to understand performance in dairy cows bred to beef sires and feedlot and carcass performance of beef on dairy calves by Foraker et al., (2021) concluded that the U.S. beef and dairy industries alike should encourage production of terminal beef on dairy calves rather than continued inefficient production of Holstein steers. Efficiency savings in producing beef on dairy calves make it a more environmentally conscious and sustainable production practice than production of traditional dairy calves for the beef supply chain. The highlights in the findings of that study were as follows:

- Dairy cow performance (lactation) was minimally impacted by sire type of previous conception.
- Dairy cows conceived to beef sires exhibited a 2 to 3 d greater gestation time than cows conceived to Holstein sires.
- Feedlot steer growth performance of beef on dairy steers was intermediate to beef steers and Holstein steers.
- Beef on dairy steers had lesser feed conversion and dressing percent than beef steers.
- Both feedlot closeouts and carcass data showed that beef on dairy calves produced a greater percent Yield Grade 2 (leaner) carcasses and a lower percent Yield Grade 4 (fatter) carcasses than beef calves.
- Beef on dairy carcasses exhibited less fat than those of beef steers and larger ribeyes than Holsteins.

- Carcass cutability advantages for beef on dairy did not come at a sacrifice to carcass quality, as beef on dairy steers generated a greater percent Upper 2/3 Choice and Low Choice carcasses, and a lower percent Select carcasses than beef steers.

Foraker et al., (2021) further concluded that production of beef on dairy calves has positive implications for the U.S. dairy and beef industries alike. This study demonstrates that economic incentivization of this production practice is warranted. Efficiency savings in producing beef on dairy calves make it a more environmentally conscious and sustainable production practice than production of traditional dairy calves for the U.S. beef supply chain. Moreover, this study exposes many of the still unknowns in influence of breed type (beef breed versus Holstein) on performance in crossbred beef on dairy cattle, suggesting future research of many aspects of this practice is needed. Regardless, the practice of beef on dairy is presently a viable and practical option for producers. Development of branded beef programs to create pull-through value in the supply chain may be the next long-term step in perpetuating sustainable beef production from implementation of this practice.

Impact of the Beef on Dairy Concept on Meat Quality Aspects

Frink et al., (2021) conducted a study intended to identify beef quality differences between cattle types, specific to beef x dairy crossbred cattle relative to palatability, retail display and immunohistochemistry characteristics. This study was a comparison of 3 cattle types: 1) conventional beef cattle (e.g., Angus, Charolais, Herford, etc.); 2) purebred dairy cattle (predominantly Holstein); 3) beef on dairy (50/50 F1 cross of conventional beef and purebred dairy genetics). In this study, beef on dairy cattle upgraded aspects of carcass composition when compared to other cattle types. Muscling and carcass length of beef on dairy carcasses was improved (shorter carcass length) compared to dairy carcasses, while beef on dairy carcasses were also leaner than native beef. The color stability of the beef in retail display for beef on dairy cattle was preferred to dairy cattle along with recognized improvements in tenderness and flavor performance when compared to native beef. Measurements of pH, trained, and instrumental color analysis showed that purebred dairy type cattle produced strip steaks inherently darker in color that developed discoloration more rapidly in retail display comparatively to either native beef of beef on dairy strip steaks. Great color stability in these steaks translates to a longer window of acceptability of beef in the retail sector which ultimately equates to a lower incidence of monetary discounts as well as a lesser number of steaks being discarded as a result of discoloration and/or spoilage. Sensory performance matched with shear force data indicated preference of beef on dairy strip loin steaks over strip loins from conventional beef animals. Specifically, the beef on dairy cattle produced strip loin steaks that were more tender and had higher ratings for overall flavor performance.

These differences are used to identify differences in the muscle composition resulting from genetic variations in growth and development that can be influential on characteristics such as flavor performance, steak tenderness, and color stability. Immunohistochemical differences were identified for the varying cattle types. Myosin heavy chain isoform (MHC) proportion and mean cross-sectional area of fibers were affected by cattle type. However, in this study, distinctions in eating quality between cattle types were not necessarily described by differences in MHC isoforms because beef on dairy cattle reported to have the greatest proportion of MHC IIa fibers with the greatest cross-sectional area of MHC I, IIa and IIx fibers. Even though there was little to no relationship between the measured quality characteristics and the immunohistochemical results in this work, it was identified that the beef on dairy

cattle produced a greater proportion of intermediate MHC fibers which provided some level of clarity on the intermediate nature of carcass characteristics and tenderness performance, when comparted to conventional beef cattle and purebred dairy cattle.

Frink et al., (2021) further concluded that terminal bound beef on dairy crossbreds should be of significant value to dairy farmers and consequently feeders across the U.S. in comparison to dairy type cattle as their fabricated product at slaughter is in many ways undifferentiated to native beef cattle. As a greater population of beef on dairy cattle continue to enter the fed-beef supply their product could serve as an upgrade to their contemporary cattle types in aspects of carcass composition and eating quality. Further findings indicated that beef on dairy cattle produce a product that is similar to native beef cattle in muscling, carcass length and retail display attributes while similar to dairy type cattle from the standpoint of trimness, tenderness and flavor. These differences could allow for beef on dairy cattle to be of greater value in comparison to contemporary dairy cattle to feeders, packers and retailers in the future, as their product offers distinct advantages.

Efficiency of the Beef on Dairy Model

In comparing the practices of producing beef with a purebred dairy animal versus the production of beef with a beef on dairy animal, one would have to understand that a greater level of efficiency and a reduction of greenhouse gases, including carbon dioxide (CO_2) and methane (CH_4), as a result of a considerably shorter feeding period (166 days vs. 307 days) and a greater average daily gain (ADG; 2.50 lb./day vs 3.31 lb./day). A recent estimate compiled by Cargill and Texas Tech University demonstrated that the beef on dairy model has a reduced carbon intensity emissions factor (MT CO2e/Head) that is approximately a 57% improvement, when compared to the purebred dairy beef model (Table 1). Furthermore, a shorter feeding period ultimately translate to less feed consumption requiring considerably less water and other inputs including fossil fuels required for the production of feedstuffs for livestock.

Summary

Producing beef using a beef on dairy model, as an alternative to producing beef in an all-dairy model, has demonstrated multiple advantages with no notable disadvantages. Research has demonstrated no meaningful detriments to dairy production, including reproductive efficiencies and lactation performance. In addition, the beef on dairy cattle produce beef that is more tender than and has a more desirable flavor profile than conventional beef and has a superior steak size and shape than all-dairy beef. The beef on dairy product also has a superior retail color performance with increased color stability and consumer appeal. Ultimately, the beef on dairy model has been shown to be a more efficient and sustainable means of producing beef, when compared to the all-dairy model, and shows promise for substantial reductions in feed and water consumption as well as greenhouse gas emissions.

Carbon Intensity Emission Factor Comparison for Purebred Dairy Beef Production and the Beef on Dairy Model

Carbon Intensity Emissions Factor (MT CO2e/Head)	Dairy Heifer/Steer	Crossbreed Heifer/Steer	Difference
	3.3	1.88	1.42
CARBON INTENSITY CALCULATION Carbon Intensity Metric = MT CO2e Feedlot Emissions/Head + MT CO2e Feed Emissions/Head			
MT CO2e Feedlot Emissions/Head	2.77	1.48	1.29
MT CO2e Feed Emissions/Head	0.53	0.40	0.13