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Effects of Changes in Finishing Diets and Growth Technologies on Animal Growth Performance and the Carbon Footprint of Cattle Feeding: 1990 to 2020

Research has clearly demonstrated that changes in feedlot diets and the use of growth-promoting technologies have improved growth performance of beef cattle compared with natural beef production systems.[1,2,3] In addition, these improvements in growth performance have increased feed efficiency and reduced the environmental impact of raising cattle in feedlots.[4] A 2011 study comparing the environmental impact of modern (2007) US beef production with production practices characteristic of the US beef system in 1977 showed that modern beef production requires considerably fewer resources than the equivalent system in 1977, with 69.9% of animals, 81.4% of feedstuffs, 87.9% of the water, and only 67.0% of the land required to produce 1 billion kg of beef.[5] Waste outputs were similarly reduced, with modern beef systems producing 81.9% of the manure, 82.3% of the methane, and 88.0% of the nitrous oxide per billion kilograms of beef compared with production systems in 1977. The carbon footprint per billion kilograms of beef produced in 2007 was reduced by 16.3% compared with equivalent beef production in 1977.

Recently published research (2022) estimated the effects of changes in feedlot diets and the availability of performance-enhancing technologies on growth performance and the carbon footprint of cattle feeding between 1990 and 2020.[6] These researchers developed a model to represent feedlot diets and technologies used in 1990 versus 2020 and evaluate changes in growth performance and carbon footprint. The use of byproduct feeds became more common between 1990 and 2020; thus, corn and dry roughage inclusion rates decreased. The diets contained steam-flaked corn, alfalfa hay, soybean meal, tallow, and supplement in 1990, and in 2020 wet distillers grains plus solubles (WDGS) replaced a portion of the steam-flaked corn and all of the soybean meal. Steam flaking was used in both years because surveys of consulting feedlot nutritionists published in 1996 and 2016 showed that it was the most widely used processing method for corn.[7,8] The 2020 diet included 20% WDGS (dry matter basis) based on the 2016 survey.

Technologies reported in the 1990 model included no technology, growth-promoting implants (estradiol only), ionophores, and the use of both implants and an ionophore in combination. In contrast, the 2020 model included no technology; implants (combinations of trenbolone acetate and estradiol); ionophores; implants and ionophores in combination, β-adrenergic agonists (βAA, in the final 28 to 42 days), and the combination of implants, ionophores, and βAA. Monensin was selected to describe the effects of ionophores in both 1990 and 2020 since it is the most widely used ionophore in feedlot cattle diets. Ractopamine hydrochloride was used to model the performance improvements associated with βAA administration because it was the only βAA used in the United States in 2020.

These authors reported that in both 1990 and 2020, the use of all available technologies increased final body weights (BW), average daily gain (ADG), feed efficiency (Gain:Feed ratio), and hot carcass weight compared with no technology. They noted that because of the differences in management practices and available technologies incorporated into the cattle management system from 1990 to 2020, direct comparisons of production outcomes between 1990 and 2020 should be interpreted with caution. However, the use of all technologies (implant and monensin in 1990 and implant, monensin, and ractopamine hydrochloride in 2020) best represents the practices used in the majority of feedlots and should be representative of the cattle fed in each time period.

Therefore, comparisons between 1990 and 2020 only describe the combination of all available technologies within each year. From 1990 (Table 1) to 2020 (Table 2), the initial BW, final BW, and hot carcass weight (HCW) increased by 7.5 (739 vs. 794 lb), 22.4 (1180 vs. 1444 lb), and 24.3%

(743 vs. 856 lb), respectively. In addition to the increase in final BW, ADG increased 11.5% (3.64 vs. 3.26 lb/day) with an increase in dry matter intake of 2.9% (19.80 vs. 19.25 lb/day). This resulted in an 8.2% increase in Gain:Feed (0.184 vs. 0.170). Total days on feed increased by 44 days from 1990 to 2020 (179 vs. 135 days).

Table 1. Growth performance model and carbon footprint [lb of CO_2 equivalents (CO2e) per animal] of feedlot cattle finished using different technologies available in 1990.

Item	No Technology	Imp[1]	Mon[2]	Imp & Mon
Initial BW, lb	739	739	739	739
Final BW, lb	1103	1180	1103	1180
Days on feed, days	137	137	134	135
ADG, lb	2.67	3.22	2.71	3.26
DMI, lb	18.85	20.02	18.10	19.25
Gain:Feed	0.142	0.161	0.150	0.170
DP[3], %	63.16	63.00	63.16	63.00
HCW, lb	697	743	697	743
Total CO_2e, lb	2122.56	2250.25	1969.15	2106.24
lb of CO_2e/lb of BW gain	5.83	5.10	5.41	4.78

[1]Cattle received a growth-promoting implant that contained estradiol twice during the finishing period.
[2]Cattle received monensin.
[3]DP = Dressing percent.
Adapted from Crawford et al., 2022.

Table 2. Growth performance model and carbon footprint [lb of CO_2 equivalents (CO2e) per animal] of feedlot cattle finished using different technologies available in 2020.

Item	No Technology	Imp[1]	Mon[2]	Imp & Mon	RH[3]	Imp, Mon, & RH
Initial BW, lb	794	794	794	794	794	794
Final BW, lb	1327	1427	1327	1427	1345	1444
Days on feed, days	182	183	181	179	185	179
ADG, lb	2.93	3.44	2.95	3.53	2.98	3.64
DMI, lb	19.60	20.46	19.07	19.80	19.71	19.80
Gain:Feed	0.150	0.172	0.154	0.179	0.154	0.184
DP[4], %	63.34	63.66	63.34	63.66	63.68	64.00
HCW, lb	840	908	840	908	856	924
Total CO_2e, lb	3036.26	3187.44	2905.77	2979.68	3105.92	2978.78
lb of CO_2e/lb of BW gain	5.68	5.04	5.45	4.72	5.65	4.58

[1]Cattle received a growth-promoting implant that contained trenbolone acetate and estradiol twice during the finishing period.
[2]Cattle received monensin.
[3]Cattle received ractopamine hydrochloride the last 28 days of feeding.
[4]DP = Dressing percent.
Adapted from Crawford et al., 2022.

Compared with no technology, use of technologies in both 1990 and 2020 decreased total greenhouse gas emissions per animal (CO_2 equivalent, CO_2e). Since cattle had greater days on feed in 2020, all sources of greenhouse gas emissions per animal increased compared with the values estimated in 1990. However, when expressed as CO_2e/lb of BW gain, emissions decreased by 4.4% because of greater total BW gain in 2020 versus 1990. Overall, feedlots in 2020 produced 47.5% more BW gain with 1.4% less cattle, while only increasing total CO_2e by 39.5%.

These researchers concluded that “based on the estimates reported in this study, incorporating the use of growth-promoting technologies into the beef feedlot production system improves performance of finishing cattle”. Even though, concerns regarding the use of products such as implants, ionophores, and βAA have become prevalent in recent years, previous research indicates that these conventional management practices improve feedlot cattle production and decrease the environmental impact. This study also suggests that these management strategies decrease the C-footprint of beef feedlots. The disproportionate increase in BW gain compared with CO_2e indicates that feedlots are decreasing the environmental impact intensity and improving efficiency, while continuing to meet the protein needs of a growing population. Therefore, changes in available technologies and diet formulations have improved efficiency and reduced the carbon footprint of feedlot cattle production in the past 30 years.

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