Impact of 50 Years of Beef Technologies

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Introduction

Beef cattle producers utilize technologies to improve animal performance, well-being, and enterprise profitability. Utilization of technologies in the beef industry is a major contributor to the safe, wholesome, and affordable beef supply in the United States. The accumulated use of technology in the beef industry has improved cattle and enterprise efficiency and decreased the resource inputs of feed and land.

Important technologies that have been adopted include: antibiotics, implants, ionophores, parasiticides, genetics, vaccines, physiological modifiers, and nutrition. The adoption rate is high because of the efficacy and return on investment, but varies between segments of the beef industry (Lawrence and Ibarburu, 2008). The improvements in beef cattle production can't be attributed to any individual technology. However, incorporation of multiple technologies in several segments of the beef industry has transformed the U. S. beef industry. Following is a brief evaluation of the effect that individual technology has on beef production.

Antibiotics

Antibiotics are utilized in two distinct methods in the beef cattle industry. Sub-therapeutic use involves low-dose levels, generally included in the feed or water. In this application, antibiotics are utilized to increase growth rate and improve feed efficiency (Elam and Preston, 2004). The growth promoting mechanism of sub-therapeutic antibiotics occurs through manipulation of the microorganism in the rumen. The manipulation of the microorganism population and function results in improved digestion, metabolism, and absorption of nutrients. The increase in feed utilization means that the animal needs less feed and produces less waste. Use of sub-therapeutic antibiotics elicits a 7% increase in feed efficiency (Table 1; Elam and Preston, 2004) and 7% increase in average daily gain (ADG; Elam and Preston, 2004; Lawrence and Ibaruru, 2008). The effect of sub-therapeutic antibiotic use has an estimated cost of production impact of $9.57/animal or 1.22% of the cost in the stocker sector (Lawrence and Ibaruru, 2008). In contrast, in the feedlot sector antibiotic use has a smaller cost of production impact ($5.86, 0.56%; Lawrence and Ibaruru, 2008).

Therapeutic use of antibiotics results in healthier cattle. The use of antibiotics combats bacterial diseases, reduces morbidity and mortality. A decrease in the incidence and severity of disease and death improves cattle production efficiency and cattle well-being. The increase in use of antibiotics in the cattle industry is similar to the use in human medicine (Elam and Preston, 2004). The use of therapeutic antibiotics is important to modern beef cattle production because of the increased use of high-grain diets, co-mingling of cattle, and scale-size of many modern beef enterprises. Wileman et al (2009) estimated that metaphlaxis use of antibiotics in feedlot cattle compared to non-treated cattle increased ADG by 0.25 lb/d, decreased morbidity from 55% to 29%, and decreased mortality by 50% (3.8 compared to 1.8%).

Implants

Implants used for growth promotion are one of the earliest and most revolutionary technologies adopted by the beef industry (Elam and Preston, 2004). Implants can be utilized in every segment of the beef production industry (cow-calf, stocker, and feedlot) and provide a benefit for all aspects of the beef industry. Implants tend to have the largest impact in the feedlot sector, but their effectiveness in all segments is important. Estrogenic implants function to metabolically enhance nutrient use thereby enhancing the growth performance of implanted cattle. Androgenic containing implants have an additive effect to the estrogen that it is combined with to enhance muscle growth along with the enhanced growth performance.

The estimated impact of implants in the stocker segment indicates nearly a 13% impact on stocker ADG (Table 1; Lawrence and Ibaruru, 2008). Additionally, implants account for 2.31% effect on the breakeven price in the stocker system that translates to a cost of production impact of $18.19 cost per head (Lawrence and Ibaruru, 2008). Industry standard implant programs in feedlots typically increase ADG by 15 to 20% (0.55 lb/d) and improve feed efficiency by 8 to 12% (Lawrence and Ibaruru, 2008; Elam and Preston, 2004; Wileman et al., 2009). Likewise, implants account for a 6.52% effect on the breakeven price in the stocker system that translates to a cost of production impact of $68.59 per head (Lawrence and Ibaruru, 2008). Implants also function to attenuate fat deposition in beef carcasses, increase ribeye area, and increase total lean tissue. Increases in carcass yield and lean tissue result in decreased cost of gain benefitting both the producer and beef processor. Lawrence and Ibaruru (2008) estimated that if implants were removed completely from all segments of the beef industry it would result in a 7.14% increase in breakeven price and a $71.28 increase in the production cost per animal. Wileman et al. (2009) estimated that not using implants in the feedlot would result in a $77 increase in the cost of production for feedlot steers.

Ionophores

Ionophores (monensin-Rumensin®, lasalocid-Bovatec®, laidlomycin propionate -Cattlyst®) are used in the feeds of cattle to affect the microbial population in the rumen. Ionophores function by selecting against or negatively affecting the metabolism of certain bacteria in the rumen. The affected bacteria are those that decrease rumen digestive physiology and the energy supply from the ruminal digestion feedstuff. By controlling detrimental bacteria in the rumen less waste products are formed, beneficial bacteria are more efficient, and more beneficial organic acids and microbial protein are formed for the cattle to metabolize. Therefore, an increase in the overall energy status of the animal is observed and the cattle actually become more efficient. Ionophores can be fed to any class of cattle and can be utilized in any segment of the beef cattle industry. Similar to many other feed additives, ionophores are fed in very small amounts and supplied in another feedstuff as carrier for intake. Ionophores are also utilized to decrease the incidences of coccidiosis, bloat, and acidosis.

In the stocker cattle segment and replacement heifers the use of ionophores increases ADG by 5 to 15% and improves feed efficiency by 8 to 12% (Lawrence and Ibaruru, 2008; Elam and Preston, 2004). The economic effect on stocker cattle is less than implants, contributing an impact of 1.46% on the breakeven price, and $11.51 effect on the cost of production. In the feedlot, ionophores improve ADG by 1 to 6% and improve feed efficiency by 3.5 to 8% (Lawrence and Ibaruru, 2008; Elam and Preston, 2004). Similar to the stocker sector, ionophores in the feedlot contribute a smaller but significant effect on breakeven price and production cost per head differential (1.18% and $12.43, respectively) compared to not using ionophore technology. Production practices that combine the use of ionophores and implants likely result in a synergetic effect (Elam and Preston, 2004) on growth performance of cattle. Ionophores increase the amount of energy available from the diet and the application of implants stimulate lean tissue growth which utilizes the increased available energy.

Parasiticides

Parasites are a diverse group of pests that generally decrease the performance and value of cattle afflicted by them. Internal parasites affect cattle through a decrease in feed digestion and increased energy requirements and both combine to result in a decrease in feed efficiency, body weight gain milk production, and conception rate in growing and mature cattle. Additionally, the deleterious effects of a parasite load on cattle can depress the overall health and immune system of cattle which can result in secondary incidents of viral and bacterial disease. There are wide spectrums of product that can be utilized to treat and control parasites. The literature is conflicting in the positive and/or non-effects on cattle production. Other work will address the specifics of flies and internal parasites directly. Regardless some general benefits compared to non-use of parasiticides were summarized by Preston and Elam (2004).

- Cow body weight and condition score increased (20 to 30 lbs and 0.2 to 0.4 units, respectively).
- Cow conception rate increased.
- Calf weaning weight increased (20 to 40 lbs)
- Heifer growth rate (0.1 lb/d), pubertal status (33% more reach puberty) and conception rate (+31%) at 14 months are improved.

Analysis by Lawrence and Ibaruru, (2008) indicated that de-worming had 17.79% positive impact on stocker cattle ADG (Table 1). Likewise, de-worming had a significant effect on breakeven price and production cost per head when utilized. In the feedlot the positive effect of de-worming continued, having and estimated 5.6% impact on ADG and 3.9% improvement on feed efficiency. De-worming had the second largest economic effect in the feedlot (2nd to implants) on breakeven price and production cost per head.

Physiologic Modifiers – Beta Agonist

Beta-agonist also mis-named as “repartitioning agents” act to increase lean muscle yield and decrease fat deposition. Actually, β-agonist act to increase protein synthesis, decrease protein degradation, and block fat cell growth. The β-agonist doesn’t shunt nutrients from fat accretion to muscle accretion, but rather affect the protein and adipocyte enzyme activity. Generally, a β-agonist is fed during the last 4 to 6 weeks of the finishing period. Utilizing a β-agonist can improve feedlot ADG by 14 to 25% and increase feed efficiency by 13 to 25% (Lawrence and Ibaruru, 2008; Elam and Preston, 2004). An added benefit is that carcass lean gain is also improved by nearly 70% during the β-agonist feeding period (Elam and Preston, 2004). Use of β-agonists decreases feedlot breakeven price by 1.24% and decreases feedlot cost per head by $13.02 (Table 1; Lawrence and Ibaruru, 2008). Additionally, the utilization of β-agonist is additive to the response of implants and ionophores. The overall effect of β-agonist as percent is decreased because they are used for a short period of time (Elam and Preston, 2004), compared with other technologies.

Vaccines

Vaccines are some of the oldest technologies utilized in the beef cattle herd. Vaccination against bacterial and viral diseases is prophylactic and must be administered before exposure of the animal to the pathogen. Vaccines are pathogen specific and many products are compounded so that one retail product can address several pathogens. Vaccines demonstrate effectiveness only when the pathogen is present in the animal’s environment, whereas if the pathogen is not encountered the vaccine has no beneficial effect. Significant vaccines of interest include: blackleg, bovine rhinotracheitis (IBR), bovine viral diarrhea (BVD), bovine respiratory syncytial virus (BRSV), parainfluenza, costridium perfringes, haemophilus, pasteurella, and leptospira. For some of these vaccinations it can be difficult to quantify the benefits in normal production. For other vaccinations, the benefit is readily discernable or the lack of vaccination results in obvious production decreases. Numerous studies have examined the relationship between health status (vaccination titer) and performance in the feedlot. Fulton et al. (2002) is one example that examined the relationship of vaccination program on feedlot performance. Direct relationships between health and performance were evident for: total treatment costs, net value, gross margin, ADG, and carcass grade.

Genetics

Beef cattle genetics over the last 50 years has exhibited both long-term planning and short-sighted reaction to trends. The movement of beef cattle genetics has generally been to create a cow herd that fits the vast differences among production environments and create a calf that can enter a feedlot to produce a beef product to satisfy perceived consumer demands. Early in the past 50 years the genetic pool was dominated by early-maturing, excessively fat, compact-compressed English breeds. Changes in carcass processing led to a move to leaner, less fat covered carcasses. The need to manipulate the carcass led to the introduction of exotic Continental breeds. These breeds altered carcasses, increased ADG and feed efficiency, and increased the final mature bodyweight of finished cattle and the cow herd in general. Utilization of crossbreeding programs has had an extraordinary positive benefit to the beef industry regarding cow herd productivity, calf growth, and beef products.

Evaluation mechanisms for genetic potential are equally utilized in the past and today. Sponsored bull test stations have traditionally been used to evaluate bull genetic merit for growth attributes. Likewise with the advent of ultrasound technology, carcass attributes can be assessed on these growing animals. Residual feed intake (RFI) is an evaluation tool that is gaining in popularity for both sires and dams in the beef industry. RFI evaluates the cattle's potential for efficient feed intake relative to growth. Genotyping or DNA profiling is becoming more commonly available. DNA profiling is often utilized in multi-sire herds to establish paternity. Less proven (accuracy and precision) technology includes genetic markers, genetic mapping, and gene expression. Limitations of genetic evaluation mechanisms is that many of the traits that are of value in the beef industry are lowly heritable, influenced by multiple genetic inputs, influenced by the animal's environment, or all combinations of the previous mentioned.

Nutrition

In some aspects nutrition technology has progressed over the last 50 years, however many of our nutritional practices remain unchanged. Genetic progress has changed the nutritional requirements of the cow herd and growing cattle. Larger cattle with heavier mature body weights and greater growth rates have increased the nutrients requirements of the cow herd. Recently the role of fat supplementation has been examined to facilitate reproductive performance. Similarly, the use of melengestrol acetate (MGA) to regulate the estrus cycle of heifers and cows has aided in application of breeding technology. However in the cow-calf and stocker sector forage-based production systems are still the predominant mechanism to manage and feed cattle.

Utilization of feed by-product feeds is one of the largest, new, and expanding opportunities. Evolution of corn processing has made by-products including corn gluten feed and distillers grains in the wet and dry form important feed resources for beef cattle production. Other by-product feeds are utilized on a national, regional, and local basis. By-product feeds are utilized by every segment of the beef cattle industry as economical means of providing energy, protein, fat, and minerals. Additionally, the evolution of corn grain processing in the feedlot has occurred. Corn grain now is routinely processed in some manner prior to mixing in the feedlot ration. Processing includes grinding, high-moisture, or steam-flaked corn. The inclusion of many feed additives in the feedlot diet has facilitated the increased level of corn processing and inclusion of greater amounts of corn in the feedlot diet. Tylosin as an antibiotic feed additive that is included routinely in feedlot diets, coupled with an ionophore is a common practice in the feedlot industry. Other advances in feed technology that have proliferated include chelated/organic source minerals and direct fed microbial products.

Conclusion

Preston and Elam (2004) estimated that productivity of the U.S. beef herd has increased by over 80% in the last 50 years. Much of the increase, but not all, in productivity can be attributed to the development and adaption of technologies to improve beef production. Antibiotics, implants, ionophores, β-agonist, prasiticides, vaccines, genetics, and nutrition all make important contributions to the efficiency of beef production. Additionally, increases in grain and forage crop yields, and decreases in relative feed prices have been important to spur the economic momentum of the beef cattle industry.

Elimination of the production technologies would represent a large setback for U.S. beef production. Lawrence and Ibarburu (2008) estimate elimination of just 5 technologies (parasite control, implants, sub-therapeutic antibiotics, ionophores, and β-agonists) would increase per head production costs by $360 over the lifetime of an animal. Likewise selling price for finished cattle would have to increase by 36% to offset the cost across all of the beef production segments. Modeling by Lawrence and Ibarburu (2008; Table 2) estimate an elimination of beef technologies would result in a 14% smaller calf crop, 18% decrease in beef production, 180% increase in beef imports, and a 13% increase in retail beef prices. Additionally, if the level of production was expected to be maintained, additional land areas would have to be incorporated for cow herd management and feedstuff production. The increased land area dedicated to beef production and associated feed production would mean more land area put into intensive agricultural production, potentially affecting environmental issues.

Literature Cited

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Table 1. Effect of utilizing technologies on average daily gain (ADG) and estimated cost of production in the stocker and feedlot segment compared to no use.[1]

Technology	ADG, %	Breakeven price, %	Cost per head, $
Stocker Sector			
Implants	12.85	2.31	18.19
Ionophores	7.74	1.46	11.51
Sub-therapeutic antibiotics	6.87	1.22	9.57
De-wormer	17.79	2.74	20.77
Fly control	8.09	0.80	6.28
All technology		10.40	80.79
Feedlot Sector			
Implants	14.13	6.52	68.59
Ionophores	2.90	1.18	12.43
Antibiotics	3.37	0.56	5.86
Beta-agonists	14.04	1.24	13.02
De-wormer	5.59	2.11	22.16
All technology		11.99	126.09

[1] Adapted from Lawrence and Ibarburu (2008).

Table 2. Model estimation of effect of beef technology ban after 5 years[1].

	Values after 5 years			
	With Technology	Without Technology	Difference	% Change
Inventory (Million cattle)				
Beef Cows, Jan 1	32.9	33.0	0.1	0.2
Total Calf Crop	37.8	32.5	-5.3	-14.1
Steer and Heifer Slaughter	27.2	22.6	-4.5	-16.5
Cattle and Calves, Jan1	95.4	83.7	-11.7	-12.2
Cattle on Feed, Jan 1	13.7	11.4	-2.3	-16.9
Beef Supply and Use (million lbs)				
Production	24,784	20,225	-4,545.6	-18.1
Net Imports	2,901	5,123	2,180.1	180.7
Retail Consumption (lbs)	35.4	59.9	-5.6	-8.5
Prices and Returns				
Finished Steers	87.28	104.94	17.33	20.2
Feeder Steers	120.02	147.48	26.52	22.8
Utility Cows	54.36	67.72	13.09	25.3
Retail Beef ($/lbs)	4.09	4.63	0.53	13.1
Cow-calf Returns ($/cow)				
Receipts	584.51	627.28	40.77	7.0
Expenses	446.17	491.29	45.94	10.1
Net Returns	138.34	135.99	-5.17	-7.9

[1]2005 prices as base, adapted from Lawrence and Ibarburu (2008).