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ENHANCING BEEF PRODUCTION EFFICIENCY THROUGH STEROID IMPLANTS

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ABSTRACT

Steroid implants have become an essential tool in modern beef production, enhancing growth performance, feed efficiency, and carcass quality in cattle. These implants, containing estrogenic or androgenic compounds, work by elevating circulating levels of somatotropin and insulin-like growth factor-1 (IGF-1), stimulating muscle growth and improving nutrient utilization. The classification of implants by potency and release profile—coated vs. non-coated—plays a critical role in determining their effectiveness across various phases of cattle development. This review examines the impact of implant strategies during the nursing, stocker, finishing, and lifetime phases of beef cattle, with an emphasis on timing, formulation, and reimplantation protocols. The integration of implant use has shown to increase average daily gain, carcass weight, and feed conversion rates, particularly when using combined hormone treatments. However, improper application may result in reduced marbling, undesirable carcass traits, or implant-related abnormalities. Furthermore, lifetime implanting strategies and phase-specific protocols must consider factors such as nutrition, genetic potential, and production goals. Regulatory oversight ensures the safety of implants for human consumption, while environmental studies show that their use significantly reduces the carbon footprint, land usage, and water demand in beef production. Despite minor risks and management challenges, the economic and environmental benefits of steroid implants support their continued use. This review highlights the importance of strategic, science-based implanting practices to optimize performance, maintain meat quality, and sustain global beef production.

Keywords: Steroid implants, Beef cattle growth performance, Hormonal growth promotants, Carcass quality, Sustainable beef production

INTRODUCTION

Implants are small pellets that contain a growth stimulant that is slowly released over a period. Implants work by raising the levels of somatotropin and insulin-like growth factor 1 in the bloodstream, which stimulates the secretion of growth hormone and promotes muscle growth. Among the hormones used in beef cattle implants, three are naturally occurring (estradiol, progesterone, and testosterone), while two are synthetic (zeranol and trenbolone acetate (TBA)). Estradiol, progesterone, and zeranol are estrogenic, meaning they influence female traits, while testosterone and trenbolone acetate are androgenic, affecting male traits. Zeranol acts similarly to estradiol, and trenbolone acetate mimics testosterone (Lawton, 2017).

Classification of Implants

Implants have been classified into low, medium and high-potency implants (Johnson and Beckett, 2014), or as coated and non-coated implants.These implant products are administered subcutaneously on the back side of the animal's ear. Once a non-coated implant is properly administered, the anabolic compound is gradually released into the bloodstream from the excipient over a period of 60–120 days, a process known as implant payout (Mader 1998). Several factors can influence the release of anabolics from the excipient, including the types of excipient compounds used in the implant formulation (such as cholesterol or lactose), the pressure applied during pellet formation, and certain polymers that delay or slow the release of anabolic compounds into circulation (Lee *et al*., 2000; Cady *et al*., 2002).

Mechanism of action

Estrogenic implants increase the circulating levels of somatotropin (ST) and insulin-like growth factor-1 (IGF-1). Both substances are naturally produced by the animal and significantly impact how nutrients are utilized to build muscle, bone, and fat. The approved androgenic agent, trenbolone acetate (TBA), does not appear to stimulate somatotropin (ST) production, but it does notably increase circulating levels of insulin-like growth factor 1 (IGF-1) and reduces the normal loss of muscle tissue in animals. The response to implants depends on the availability of nutrients and the concentration of the growth promotant in the animal's system. When a growth-promoting implant is initially placed, there is a rapid release of the hormone, which starts to decline after a few days. However, the level of the growth promotant remains above the threshold needed to stimulate growth for a varying period, depending on the implant's pharmaceutical design and the quality of its administration. Reimplanting, or administering another implant, is typically timed to coincide with the decline in circulating growth promotant levels, while still above the threshold. This optimal timing for reimplanting is called the "reimplant window." For maximum benefit, it is essential to keep the growth promotant levels above the threshold throughout the ownership of the stocker or feeder animal (Zobell *et al*., 2000). A study by (Reichhardt *et al*., 2021*)* suggested that concentration of hormones plays an important role in determining carcass quality and average daily gain. In their study, average daily gain, body weight, hot carcass weight and feed efficiency were greater for Angus steers implanted with a combination of estradiol (ES) and trenbolone acetate (TBA) than with trenbolone alone and with the steers without implants. However, their study could not achieve similar result with ES alone.

Effects of Implants in different phases Beef Production

1) Nursing Calves

Implant products are available for calves weighing less than 400 pounds (181.43 kg).Implants approved for use in nursing calves generally contain a lower dose of the active ingredient compared to those approved for older cattle. These implants are typically administered when the calves are between 2 and 4 months old (Beck *et al*., 2022). However, a study by Webb et al. (2017) found no significant changes related to the timing of implant administration. Additionally, their research on steers showed no notable differences in live performance, carcass traits, or meat quality.They also suggested that the nursing or suckling calves should be on high nutrition for estimating the effects of these implants. In contrast to the above study (Pritchard *et al*., 2015) demonstrated that age of dam is an important factor for determining the body weight of weaned calves. Additionally, they were able to achieve 22-pound (9.97 kg) heavier claves when implants were inserted as compared with the non-inserted calves. These calves were nursed by mature dams as compared to immature cows.

2) Bull Calves

Most research studies claim that bull calves produce more lean meat than steers, but due to some behavioural problems such as riding, pasture and fence damage, and injuries, producers around the world doesn't prefer bulls for meat production. Despite that, researchers like (Mckenzie, 1983) have revealed a solution for increasing meat production using bulls.In his study, a zeranol implant used for 70-day period not only brought controlled bull behaviour but also produced bulls with 4.8% faster growth than the un-implanted bulls. Also, the carcass evaluation of the trial bulls slaughtered indicated definite hindquarter muscling improvement, along with larger tenderloin steaks. Additionally, his work suggested that implanting frequently about 40-50 days apart can increase sexual retardation so that increased body weight gain and high carcass yield of the bulls can be achieved.

3) Heifers

To understand whether the effect of implants on growth issex-dependent (Ribeiro *et al*., 2021) found out that implanting TBA can have a greater influence on steers than heifers. But, in their study heifers implanted with TBA had higher dry matter intake (DMI), Average daily gain (ADG), gain to feed ratio (G/F), carcass weight (CW), dressing percentage and ribeye area. This study demonstrates the effect of implants in heifers too. The DMI for implanted v/s non implanted was 10.58 kg. d^{-1}v/s 9.8 kg. d^{-1} ;ADG was 1.58kg v/s 1.37kg; G/F was 0.149 v/s 0.141; CW was 390 kg v/s 360 kg; dressing percentage was 60.8% v/s 59.9%; ribeye are was 92.6 cm^2 v/s 84.6 cm^2 respectively. Interestingly, an experiment done by (DeeHan *et al*., 1990) put forward a combination strategy of implanting steroids in heifers to increase the carcass quality. Accordingly, a combination of testosterone treatment prenatally and implanting testosterone and estradiol postnatally can have marked improvement on daily gain, feed efficiency and carcass merit of heifers. Agreeably, their study could reveal increased daily gain of 10.4% (prenatal administration of testosterone) and 16.4% increase of daily gain (postnatal administration of testosterone) respectively. While an increase in feed efficiency of 12.9% was obtained when testosterone was administered prenatally. However, an increase in 9.5% of feed efficiency was observed, when post-natal implantation of testosterone was done. Similarly, an increase in ribeye area and weight of liver were also evident when this combination was used.

4) Stocker Calves

Stocker calves refer to weaned calves grazing pasture to enhance growth prior to finishing and slaughter; they are usually younger, weigh less, and are of lower condition (finish) than feeders. A study by (Richenson *et al*., 2015) demonstrated different timing of administration of implants in stocker beef calves. In their study, though they where not able to highlight any increase in average daily gain and birth weight during the 42-dayreceiving period, they were able to increase the overall average daily gain in their subsequent grazing period for implanted calves. Through their study it was exposed that, there is no objective of delaying implantation in stocker calves when they are newly received. As implantation does not have a direct effect on these calves. Some researchers suggested that using implants in stocker calves may reduce marbling score and quality grades and as these traits depends largely on potency and duration of implants.For example, a study by (Garcia *et al*., 2023), used different potent implants for analysing carcass characteristics. The implants used in their study were a) Synovex One Grower (Zoetis) containing 150 mg trenbolone acetate and 21 mg estradiol benzoate) this implant is having a payout of 200 days as per the label and is also classified under extended-release implant. b) Conventional grazing implant known as Component TE-G (Elanco) with tylan containing 40 mg trenbolone along with 8 mg estradiol and 29 mg of tylosin tartrate. For reimplanting, 2 components of Component TE-G were used. Though, the performance of cattle such as ADG, gain per animal was high, the carcass characteristics did not find any significant changes during the experiment. The carcass qualities such as hot carcass weight (HCW), rib eye area did not show any significant result. In this study, they also had negative marbling scores. As a conclusion, this study recommended that, at the stocker phase of production implanting with single component TE-G is the most effective.

5) Finishing Cattle

In the U.S., implants are widely used in the feeding industry to enhance average daily gain (ADG) and feed efficiency. The finishing period typically lasts between 120 and 240 days. A single implant can increase ADG by 0.35 pounds (0.15 kg) per day in steers and 0.25 pounds (0.11 kg) per day in heifers. Feed conversion may improve by 0.5 pounds (0.22 kg) of feed per pound of gain. Aggressive implant programs in feedlots can lead to up to a 21% improvement in daily gain and an 11% improvement in feed conversion (Beck Paul et al. 2022).A study involving about 13640 animals was conducted by (Guiroy *et al.,* 2002) indicated that raising the anabolic implant dose raises the weight at which animals achieve a uniform body composition. The data summary indicates finished body weight is increased from 14 to 42 kg in steers and 30 to 39 kg in heifers, depending on the implant strategy used, to reach the same body composition at harvest as unimplanted animals.

Effect of implanting for life - time

The main goal of an integrated beef production system is to minimize overall production costs.Choosing the appropriate implant depends on several factors, including available resources, cattle type, age at slaughter, and the pricing grid at slaughter.Along with that palatability of end product and quality grade should also be considered. Without proper understanding of implanting strategies at different phases of production can lead to reduced profitability of the production system (Duckett and Andrae, 2001). In the modern beef industry, it is a common practice for giving implants 3 or 4 times throughout the life the animal. It is economically feasible for producers who runs only one phase of the industry. But there are producers who retains the animal for two or more phases of production, implanting is a complex process. Another important aspect of implant is the effect of carryover fromone phase to another phase of production, it may cause deleterious effect in the carcass quality. As a result, the common practice of achieving lifetime implanting is by adopting an implanting protocol involving a combination of low, moderate and high potent implants. Low potent implant is preferred in the suckling phase, followed by one or two moderate implants in the growing phase. When the animal reaches the feed yard implanting using moderately potent implant is used. Finally, a high-potency implant 80 days to 100 days before slaughter is advised (Beck *et al*., 2022). In consideration of the above strategy, a study by (Prouty and Larson, 2010) compared the effect of one-time implant (Revalor -XS) with the effect of 2 reimplantation scenarios (Synovex Choice + SynovexChoice, Synovex Choice + Synovex Plus) on feedlot steer performance and carcass traits for 160 days. All the above implants contain trenbolone acetate and estradiol. Accordingly, this study demonstrated that 2 reimplantation scenarios are better than one-time implanting strategy. During their study, implanting Synovex choice at 0th day followed by reimplantingSynovex plus on 70th day produced more gain to feed ratio, cost of body weight production was 4 % lower, Hot carcass weight was 6 – 7 kg more than other implanting scenarios. However, carcasses grading USDA Prime + Choice tended ($P = 0.08$) to be greater for cattle implanted with Synovex choice on 0th day followed by Synovex choice on 79th day than for those implanted with Synovex Choice + Synovex Plus.

Safety of implants

Prior to use the implants in commercial practice, agencies such as FDA (US Food and Drug Administration), USDA/FSIS (The United States Department of Agriculture-Food Safety Inspection Services) and JECFA (Joint Expert Committee on Food Additives of the Food and Agriculture Organization of the United Nations and World Health Organization) uses multi step scientific reviews to ensure safety for human health and consumption. Besides, the JECFA has established maximum residue levels (MRL) for xenobiotic compounds (i.e. trenbolone acetate and zeranol) and has set for average allowable daily intakes (ADI) for natural compounds, such as estradiol-17β and testosterone propionate. (Smith and Johnson, 2020).

Environmental Impacts of using implants

Capper and Hayes (2012) demonstrated effectively how removal of growth - enhancing technologies (GET) from US beef production impact negatively to the environment. In their study, they found out that withdrawing GET from U.S. beef production reduced productivity (growth rate and slaughter weight) and increased the population size required to produce 454×10^6 kg beef by 385×10^3 animals. Feedstuff and land use were increased by $2{,}830 \times 10^3$t and 265×10^3 ha, respectively. Furthermore, GET withdrawal, with $20{,}139 \times 10^6$ more liters of water being required to maintain beef production. In addition, manure output increased by $1{,}799 \times 10^3$ t. Apart from that,because of GET withdrawal, an increase in carbon emissions of 714,515 t/454×10^6 kg beef produced was also recorded. The GET systems in their study used steroid implants, in-feed ionophores, in-feed hormones, and beta-adrenergic agonists. Through their study, it was recommended that by providing sufficient safe, affordable, nutritious beef to current and future generations, with concurrent reductions in environmental impact, the use of GET within beef production enhances sustainability, rather than simply maintaining it.

Abnormalities associated with Implants

Research studies revealed many abnormalities associated with implants (Crawford, 2021) highlighted that the most common abnormality was partial implants. According to his findings, a statistically insignificant less weight gain of 0.11 lbs (0.049 kg)/day was seen in steers with partial implant as compared with steers with normal implant. Missing implants represented the second-most common abnormality and resulted in a decreased ADG of 0.49 lbs (0.22kg)/day compared with steers receiving a normal implant. The causes of missing and partial implants could be due to operator error (implants pellets being pushed through the ear or the implant gun being pulled out too quickly), an empty implant cartridge, or abscesses that are developed due to local infection at the implant site. The abscess issue is one that can be a great concern and can be avoided with proper sanitation and sanitation and care at the implant site. Other abnormalities include heavy carcass weight for large frame exotic long yearlings as suggested by (Zobell *et al*., 2000). Additionally, they also reported poor yield grades in heifers implanted with combination estrogenic-trenbolone implants and simultaneously fed the feed additive melengesterol acetate (MGA). Poor quality grades can arise if implant schedules are not properly tailored to the cattle's age, weight, genetics, and nutritional management. Additional findings included vaginal and rectal prolapses, high tailheads, sunken loins, under development, and heavier hide weights. However, these issues are generally infrequent or carry minimal economic impact when weighed against the performance gains achieved with implants.

Economics of Implant

Jaborek (2023) published the economic return of implanting in a steer. According to his findings, an economical benefit of $118.94 can be obtained from an implanted steer. The various parameters which is taken account in his study includes 1)Dry matter intake 2) Implanting Cost 3) Choice Weight gain (Total Weight Gain X Choice Live Price X 1% grading USDA choice or greater 4)Select weight Gain (Total Weight Gain X Choice Live Price X 1% grading less than USDA choice). (Capper and Hayes, 2012) suggested that removing implants can lead to a taxation of 8.2% on beef products. This can reduce global trade for beef production and reduce competition. To address this situation, it would require boosting beef production in other regions globally, which is likely to lead to increased carbon emissions due to deforestation, particularly in Brazil. Eliminating growth-enhancing technologies (GET) from U.S. beef production would undermine both the economic and environmental sustainability of the industry.

CONCLUSION

In conclusion, the application of steroid implants in beef production significantly enhances growth rates, feed efficiency, and carcass quality across different stages of cattle development. The use of both estrogenic and androgenic implants plays a pivotal role in manipulating hormone levels to optimize muscle growth, resulting in improved economic returns for producers. However, careful consideration of implant strategies and timing is crucial to avoid negative impacts on meat quality, such as reduced marbling and undesirable carcass traits. While the environmental benefits of increased productivity are notable, ensuring proper management and addressing potential implant-related abnormalities are essential to maintaining the health and welfare of cattle. Overall, the strategic use of implants remains a valuable tool in modern beef production, contributing to the industry's sustainability and economic viability.

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