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Benefits of DNA-based Technology in Beef Production

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Background

The success and sustainability of any business is directly related to operators' ability to recognize and meet the demands of whatever market that business is serving. Consumers have access to vast amounts of information upon which purchase selection is made and a global high-tech marketplace from which to obtain chosen goods. The beef industry is challenged with adapting to a global economy and satisfying the demands of the market. Emerging genetic technology coupled with traditional production practice can help producers provide the high quality products demanded by consumers while maintaining or improving the profitability of their individual operation. Genomic (DNA-based) technology can be especially helpful in two aspects of cattle production: selection of breeding population and animal identification.

Terminology

A basic understanding of genomics, the science of inheritance at the molecular level, requires one know meanings of terms used within that field of study. The following definitions will help in understanding the context of information presented in this article:

- DNA (deoxyribonucleic acid) - chemical contained in all living organisms with the information required for growth, development and maintenance. Microscopically DNA resembles a ladder that has been twisted to form a spiral (double helix). The rungs of the ladder, known as base pairs, are composed of four distinct molecules (nucleotides) identified by the letters A, T, C and G; these four molecules are arranged in long sequences that provide the codes required for life.
- Chromosomes - cellular structures each containing a single length of DNA, containing many genes, and proteins wound tightly into a compact package. Chromosomes are arranged in pairs containing one from each parent. Chromosome numbers are species specific, cattle possess 60 (30 pairs) whereas humans possess 46 (23 pairs).
- Gene - a DNA sequence that codes for a specific protein.
- Locus (plural loci) - the specific location or site of a particular gene on a chromosome.
- Allele - one member of a pair or sequence of forms of a gene which occupies a specific site on a chromosome.
- Trait - a measurable or observable characteristic of an individual, i.e., coat color, birth weight, marbling, etc.
- Quantitative Trait Loci (QTL) - a combination of genes contributing to expression of a polygenic or quantitative trait
- Genetic Markers - sequences of DNA that can be used to identify genes or individuals.
- SNPs (single nucleotide polymorphism) - a genetic marker characterized by the exchange of one nucleotide for another, for example A for G.
- Heritability - the proportion of phenotypic variation in a population that is due to genotypic variation in individuals. Measured 0 (low) to 1 (high).
- Phenotype - an observed category or measured level of a trait in an individual.
- Genotype - genetic composition of an individual.
- Polymorphism - detectable variations in the composition of a gene or trait.

Marker (DNA) Assisted Selection

Selection of breeding animals is a primary method by which genetic change is achieved within a herd; however, most economically important traits beef producers select for are influenced by multiple genes. These quantitative traits display a broad range of expression because their component gene loci are spread

between multiple chromosomes and are rarely passed to offspring in the same combination found in the parents. The complexity of quantitative trait inheritance confronts producers with the challenge of selecting breeding animals capable of achieving desired herd improvement.

Traditional selection methods rely on EPDs (Estimated Progeny Difference) and breeding values (BVs) of prospective parents, particularly sires. These values are statistically determined by past performance and pedigree. EPD accuracy is directly proportionate to the number of offspring an animal has produced. Accurate selection of replacement breeders from young bulls and heifers is difficult given their lack of progeny.

Current and emerging genetic technologies focused on economically important traits hold promise for improving producers' selection accuracy. Researchers have isolated and identified various genes associated with economically important beef traits, including some carcass traits. After a gene of interest is isolated, DNA samples from many animals are carefully evaluated to determine if different alleles of the target gene exist in the population. Differences, called polymorphisms, may involve multiple base pairs or single base pairs located in or near the target gene. These sequence difference types are called simple tandem repeats (STRs) and single nucleotide polymorphisms (SNPs); STRs and SNPs provide researchers genetic markers for identifying different alleles and phenotypes associated with them.

Producers can have potential breeding stock evaluated to determine those animals' genotype in regard to quantitative traits of interest. A molecular breeding value (MBV) is assigned based on DNA-profile results. MBVs obtained in young cattle provide producers information that is helpful for selecting which animals to keep and develop further.

Combining EPDs with DNA derived information can increase selection accuracy thereby contributing to overall increased profitability. Individual benefit of DNA-assisted selection is dependent upon the nature of the traits of interest. Categories of traits which should benefit most from DNA-assisted selection are (in order of greatest to least): disease resistance and immunocompetence, carcass quality and palatability attributes, fertility and reproductive efficiency, maintenance requirements, carcass quantity and yield, milk production and maternal ability and growth performance. Ranking is based on consideration of: 1) the relative difficulty in collecting performance data, 2) the relative magnitude of heritability and phenotype variation observed in the traits, 3) the current existing amount of performance information available, and 4) when performance data become available in the life cycle of the cow herd (collected at birth, weaning, yearling, maturity, slaughter, consumption). (1)

Estimated Heritability for Economically Important Traits in Beef Cattle (Source: Van Eenennaam) (2)

Quantitative Trait(s)	Heritability (h^2)
Reproductive	
Age at puberty	0.40
Weight at puberty	0.50
Scrotal circumference	0.50
Primary sperm abnormalities	0.30
Secondary sperm abnormalities	0.02
Calving date	0.20
Calving ease	0.15
Gestation length	0.40
Birth weight	0.40
Pelvic area	0.50
Body condition score	0.40
Calving interval	0.10
Growth	
Weaning weight	0.30
Milk production	0.20
Postweaning ADG (feedlot)	0.45
Postweaning ADG (pasture)	0.30
Efficiency of feedlot gain	0.45
Maintenance (Mem)	0.50
Yearling weight	0.40
Mature weight	0.50
Carcass	
Carcass weight (at similar age)	0.40
Carcass quality grade	0.35
Fat thickness	0.45
Yearling hip height	0.40
Yield grade	0.35
Tenderness	0.25
Shear force (WBS)	0.40
Sensory panel	0.10

*Heritabilities below 0.20 are considered low, those 0.20 to 0.39 are considered medium, and those 0.40 and higher represent highly heritable traits.

The difficulty in assessing, in prospective parents, traits that are not evident until after the animal is slaughtered presents another selection challenge. Carcass grade, marbling and shear strength are economically important properties which cannot be accurately identified until after an animal is culled from the breeding population. In the case of bulls, significant time and money are invested in young sires before enough offspring are

produced and finished to accurately evaluate production capabilities in regard to post-mortem traits. DNA technology can help identify young bulls which possess the QTLs associated with desired post-mortem traits.

Identification and Traceability

Modern consumers are increasingly conscious of the origin and integrity of their food resulting in heightened demand for traceability within the production chain. Traditional identification methods, such as tagging, are well suited for early stages of production. Ear tags are inexpensive and easy to implement, however the potential exists for misidentification of animals due to ear tag loss, clerical error and in some cases deliberate fraud. Conventional ear tags and their electronic counterparts provide little potential for positive identification once an animal enters a processing facility. DNA profiling, on the other hand, utilizes unalterable genetic sequences that are unique for every individual animal. Unlike methods that rely on devices attached to an animal or its products, use of DNA profiling uses the animal itself or its products as means of identification. DNA profiles of individuals are obtained from analysis of tissue, typically blood, semen, hair or skin, collected from animals in an early stage of production. Electronically recorded DNA profiles can be used to identify animals throughout the production process. Samples can be collected at any point, analyzed and traced to their source. (3)

Parentage

Parentage, in particular paternity, identification is another potential benefit provided by DNA profiling technologies. In production systems utilizing multiple bulls turned out with the cows, or grazing co-ops in which members each contribute bulls, identification of offspring sires can be difficult and potentially detrimental to genetic improvement in the herd. DNA profiling of calves identifies their respective sires, facilitating complete documentation of pedigree and of performance data throughout the calves' lives. Positive sire ID can help producers assess, based on offspring numbers and performance, the relative fertility of each bull. Accurate documentation of bull performance aids culling decisions and helps ensure operations progress toward herd genetic and production objectives.

Summary

Today's fast paced, high-tech, global market presents the beef industry with challenges to satisfy consumer demands while protecting the integrity and profitability of producers in every stage of the process. Continual herd genetic improvement is a vital component of industry success; implementation of emerging DNA technology into existing selection practices will improve accuracy, consistency and profitability.

Sources for beef genotyping services:

Biogenetic Services: Parentage, Freemartin, Coat Color, Leptin and Meat Quality
www.biogeneticservices.com 800-432-4163

Bovigen Solutions: parentage, genotype registry, GeneSTAR® marbling, GeneSTAR Elite Tender®, SureTRAK®(traceability), HD 50K for Angus
www.bovigen.com 877-BEEF DNA

DNA Solutions, Inc.: parentage, genotype registry, DNA banking and forensic ID www.DNAsolutionsusa.com
866-362-9778

Gene Seek: parentage, coat color, tenderness and traceability.
www.geneseek.com 402-435-0665

Genetic Visions: Freemartin, coat color, Calpain (tenderness).
www.geneticvisions.net 608-662-9170

Igenity: parentage, coat color, tenderness, meat quality, marbling. www.igenity.com 877-IGENITY

MMI Genomics, Inc.: parentage, Tru-polled®, Tru-color®, Tru-marbling®, Tru-tenderness®.
www.breedtru.com 800-311-8808

Sources

1. **Bertrand, J.K., R.D Green, and W.O. Herring.** *Genetic Evaluation for Beef Carcass Traits.* Journal of Animal Science. 2001. Vol. 79, pp. E190-E200.

2. **Van Eenennaam, A.** *DNA-Based, Marker-Assisted Selection in Beef Cattle. Cattle Producer's Library.* [Online] 2008. www.csubeef.com.

3. **Allen, A.R., M. Taylor, B. McKeown, A.I. Curry, J.F. Lavery, A. Mitchell, D. Hartshorne, R. Fries, and R.A. Skuce.** *Compilation of a panel of informative single nucleotide polymorphisms for bovine identification in the Northern Irish cattle population.* BMC Genetics. 2010, 11:5 *Biomedcentral.com.* [Online] 2010.

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