Beef Nutrition
Growth Promoters: Uses, Actions and Adjusted Nutrient Requirements

Growing Beef that are big.......and tasty!!!
Beef Production: Intent and Objective

• Provide sufficient nutrients to:
  • Support maintenance
  • Support growth of muscle
  • Support desired “finishing”

• Produce the desired commodity: “meat” in an economically efficient and profitable manner

• CAPITALIZE ON EFFECT OF GROWTH PROMOTER
Beef Cattle Nutrient Requirements

- Dependent upon:
  - Maintenance requirements/Environmental conditions
  - Weight
  - Stage of growth
  - Breed/frame size
    - (large frame cattle would be more or less fat for same weight?)
  - Desired rate of growth
Advantages of Excellent Nutrition/Ration formulation

- Improves herd health
- Improves immune response
- Improves feed efficiency
- Improves bottom line (uniformity, product quality)
- Improves rate of gain

- However need to also evaluate cost...may not need optimum/optimal...rather balanced and adequate
Feed usually accounts for the single largest input cost associated with beef cattle production. Producers can have greatest impact on reducing costs.

An understanding of the ruminant digestive process and basic nutrition is required for effective feeding and management.

Feed requirements are based on the need for specific amounts of various classes of nutrients.

- Each nutrient fulfills specific roles in growth, production or metabolism.

Nutrient classes are defined by their chemical structure or by their function in metabolism.

- ENERGY, PROTEIN, MINERALS, VITAMINS
Use of growth stimulants/promoters

- If rate of growth is expected to be altered then dietary ration needs to be adjusted to satisfy and capitalize on the additional Nutrient requirements for this growth.

- Also maintenance requirements may also be changed by the stimulant/growth promoter.
Growth
What is growth??

- Getting larger
- But body structure, composition and proportions change also (ie. adult is not just a bigger newborn)

- Growth represents both accretion and increase in size of original tissues or organs, and also re-organization, maturation, development and even alteration in function
Types of Growth

- Hypertrophy; enlargement of existing cells
- Hyperplasia; multiplication, proliferation and specialization of new cells
- Accretionary (a bit of a misnomer); increasing extracellular and intracellular material
- In production Beef what tissue(s) do we want to maximize growth??
Nutrient requirements for Growth

- Occurs when protein accretion is in excess of protein loss
- Grower rations are designed to facilitate protein accretion in a growing animal
Finishing rations are designed to facilitate simultaneous growth of lean and fat tissues, certainly includes increased inclusion of concentrate (energy dense)

Must have surplus energy to store as fat

Gain from growth is less costly than gain from fattening (why?)

Usually fattening animals are full-fed high-energy rations during the last phase of growing-finishing feeding period
NUTRIENTS ARE REQUIRED IN PROPORTION TO ONE ANOTHER!!!!

- It is uneconomical to feed any nutrient (Energy, Protein, Mineral or Vitamin) in excess of the most limiting nutrient.

- ENERGY and PROTEIN are the nutrients required in the greatest quantity for production ruminants including beef cattle.
Factors that influence growth

- Genetics
- Quality and quantity of nutrients
- Health, wellness and environment
- Exogenous growth promoters
- Sex (gender)
Protein Synthesis

Total Protein
(Accretion or loss)

Protein breakdown
Classes of Growth promoters

- **Steroids**- remember “anabolic” in nature- Zeranol, Melengesterol acetate, Trenbolone acetate, Ralgro, Revalor, Synovex

- **Catecholine mimics** (β-agonists and α-agonists)
  - Ractopamine- HCl (Optaflex), Clenbuterol (not FDA approved), Zilmax (Zilpaterol-HCl, no longer available 2013)

- **Somatotropins**- bST

- **Ionophores (antibiotics)**- Monensin, Rumensin, Tylosin

- **Micronutrients**- Chromium picolinate, polyamines
Steroids

- Used for better than 40 years (started 1970)
- Initial implants were estrogenic agents which metabolically enhanced nutrient use to enhance growth.
  - improved feed efficiency 5-10 percent and daily gains from 5-15 percent
- 1987 Trenbolone Acetate (TBA) was approved
  - had an additive effect with existing estrogenic implants
  - 2-3 percent to the feed efficiency and 3-5 percent to the daily gains
- Today, implants have become almost designer products with varied doses and combinations of estrogenic and/or androgenic agents
- Use banned in EU in 1988
Synthetic Hormones

- Trenbolone Acetate (TBA), Zeranol and Melengestrol Acetate (MGA- feed additive)
- TBA and testosterone have an anabolic biologic activity as an androgen
- Zeranol has biologic activity as a weak estrogen
- MGA and progesterone have biologic activity as a progestogen.

- These molecules are used in beef cattle growth promoting products.
- Estrogens produce the greatest responses in intact male cattle and androgens in females.
- Combinations of oestrogenic and androgenic substances produce an additive response in male cattle.
Mode of delivery: Implant

If the middle of the ear has been damaged, place implant on the top of the ear.

If the tip of the ear is missing, place implant in the outer 1/2 of the remaining ear.
Steroid implants mode of action

- Estrogenic implants increase the circulating levels of somatotropin (ST) and insulin-like growth factor-1 (IGF-1).
  - these substances are produced by the animal and affect how nutrients are used by the animal to produce muscle, bone, and fat.
- Androgenic agent; trenbolone acetate (TBA), does not stimulate the production of ST, but increases circulating levels of IGF-1 and decreases protein breakdown.
- IMPORTANT: Implant efficacy is dependent upon Nutrient sufficiency and balance and the sum of circulating anabolic steroids.
Anabolic steroids - general effects

- Increase rates of protein synthesis
- Reduce rates of amino acid oxidation and protein degradation
- Little direct effect on lipid metabolism though estrogenic hormone may be slightly associated with lipid storage
Total Protein
(Accretion or loss)

Protein Synthesis

Protein breakdown
### Examples of designer implants

<table>
<thead>
<tr>
<th>BRAND</th>
<th>SEX</th>
<th>GROWTH PHASE</th>
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<tbody>
<tr>
<td>Ralgro®</td>
<td>both</td>
<td>suckling, growing, finishing</td>
</tr>
<tr>
<td>Synovex® - C</td>
<td>both</td>
<td>suckling</td>
</tr>
<tr>
<td>Component™ E-C</td>
<td>both</td>
<td>suckling</td>
</tr>
<tr>
<td>Compudose®</td>
<td>both</td>
<td>suckling, growing, finishing steers and finishing heifers</td>
</tr>
<tr>
<td>Synovex® - S</td>
<td>steers</td>
<td>over 400 lbs., growing and finishing</td>
</tr>
<tr>
<td>Component™ E-S</td>
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<td>over 400 lbs., growing and finishing</td>
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<tr>
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<tr>
<td>Synovex® - Choice</td>
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<tr>
<td>Synovex® - Plus</td>
<td>steers/heifers</td>
<td>finishing</td>
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<td>Finaplix® - H</td>
<td>heifers</td>
<td>finishing</td>
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<tr>
<td>Revalor® - 200</td>
<td>steers/heifers</td>
<td>finishing</td>
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<tr>
<td>Revalor® - S</td>
<td>steers</td>
<td>finishing</td>
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*For cattle intended for slaughter*
The eating quality of beef from implanted and untreated cattle is similar.

Residues in the meat are low (parts per thousand billion).

Human consumption of residues from steroid growth promoters is less than those in natural dietary ingredients such as cabbage, eggs, or soy products and far below amounts of hormones produced naturally by the human body.

However, there is a risk from accidental ingestion of a whole implant, thus cattle are implanted in the ear, which is discarded after slaughter.
Protein is the primary factor important for achieving a response to estrogenic growth promoters if energy intake is above maintenance.

Both in controlled nitrogen balance trials and in an ad libitum level intake experiment when protein intake was limiting under varying but adequate energy supply, response to Synovex was reduced.

OTHER CONSIDERATIONS

- Implanting heifers intended to enter the breeding herd is controversial.
- Research suggests
  - Implant once and not younger than the age directed.
  - Select an implant approved for use in replacement heifers, providing adequate nutrition for growth, and leaving adequate time between implanting and breeding.
- Implanting replacement breeding bull calves is not approved or recommended.
Commercial production of bovine somatotropin (bST) became possible with recombinant DNA technology in the early 1980’s and tested first by Bauman et al., 1982. Data indicate that modest doses of bST in ruminants:

- Increases ADG 10-15%
- Increases feed conversion efficiency 9-20%
- Increases carcass lean content 5-10%
- Reduces carcass fat content 10-15%

Direct effect by interaction and binding with its receptors on target tissues and indirect effect by stimulating production of IGF-1.
Purified 197 amino acid peptide and administered as an injectable

Why is it not useful as a feed additive?
Physiological effects of bST

1. Skeletal muscle- increased protein synthesis, increased amino acid and glucose uptake, increased efficiency of amino acid utilization
2. Adipose tissue- decreased glucose uptake and oxidation, decreased lipid synthesis
3. Bone-increased mineral accretion
4. Liver-increased glucose output decreased sensitivity to insulin dependent inhibition of gluconeogenesis
5. Intestine- increased absorption of calcium, phosphorous and vitamin D

Murdoch et al., 2006  Metabolic modifiers in animal nutrition...
Total Protein
(Accretion or loss)

Protein Synthesis

Protein breakdown
Effect on nutritional requirements

- Efficiency of digestion, and absorption of some important micronutrients occurs with bST administration but maintenance energy requirements may rise in bST treated cattle based on increased lean body mass.

- Since protein synthesis rises in the absence of increased or decreased protein breakdown the net protein requirements may need to be elevated.
What is the natural catecholamine produced by the body??

Synthetic analogues – clenbuterol, cimaterol, isoproterenol, ractopamine and zilpaterol

These compounds vary in their absorption, half-life and metabolic clearance

Generally referred to as repartitioning agents- in favor of lean body mass over fat accretion

Ractopamine and zilpaterol are licensed to be administered as feed additives
Physiological effects of catecholamines

- Beef are prey animals
- Natural catecholamines (such as; adrenalin) mediate the ‘fight or flight’ response
- Activation of this pathway causes animal to become stronger to further enhance chances of survival.

- Muscles become stronger by becoming larger, more myofibrils in each muscle cell

- Thus synthetic catecholamines mimic the “training effect” and support muscle growth
Mode of action

- Interestingly, while there is some evidence that β-agonists increase protein synthesis the strongest evidence suggests that they decrease protein turnover towards a net affect of greater protein accretion.

- β-agonists also result in an decrease away from oxidative muscle fibers and induction of transition towards larger anaerobic muscle fibers (more efficient at protein synthesis growth)

- Rather than repartition energy they just alter the partitioning of substrates towards lean tissues rather than lipid accretionary tissues (more nutrients to muscle less to fat)
Switch to more fast twitch (type 2) muscle fibers may increase protein synthesis
Impact on nutrient requirements

- The licensed β-agonists are administered in the final 45 days of beef production.

- With the induced capacity to accrete protein, increased lean body mass is expected.

- Since this is the “finishing phase” it is desirable to induce “marbling” associated with intramuscular fat deposition, it is beneficial to increase both the dietary protein and energy in the finishing ration.
The term "antibiotic growth promoter" is used to describe any medicine that destroys or inhibits bacteria and is administered at a low, subtherapeutic dose.

High energy rations increase muscle growth and fat deposition in beef cattle. Unfortunately, such rations are associated with bloat and lactic acidosis, which can be debilitating or even fatal.

Monensin, rumensin and tylosin are feed additive ionophores that reduce the risk of lactic acidosis, bloat and associated liver abscess and also reduce ammonia production and emission (increased efficiency).
Mode of action

- help growing animal digest their feed more efficiently
- the mechanism underpinning their action is unclear, it is believed that the antibiotics may suppress sensitive populations of bacteria
- Thomke & Elwinger (1998) hypothesize that cytokines released during the immune response may also stimulate the release of catabolic hormones, which would reduce muscle mass. Therefore a reduction in gastrointestinal infections would result in the subsequent increase in muscle weight
- Most important a healthy GI tract absorbs nutrients more efficiently
Use of antibiotics in feed is a hot topic in the public, due to concern about promoting antibiotic resistance.

These ionophore antibiotics are not medically important antibiotics and thus not associated with any major resistance problems.

Rogers et al. (1997) concluded that there is no real adaptation of rumen microbes after a period of 96-146 days of monensin treatment and that most effects disappear within a few hours following monensin withdrawal.

In this sense, monensin is probably one of the safest and most effective antibiotic growth-promoters with regard to human and animal health and associated bacterial resistance problems.
Since ionophores are administered to compensate for high energy finishing rations they do not themselves require modification to the nutrients but rather facilitate efficiency of growth on these beef rations.
Polyamines (putrescine, spermidine and spermine) are not currently used as growth promoters in cattle but their positive association with cell growth and gut health may support their use in the future.

Chromium picolinate has shown promise for increasing accretion of muscle in pigs and decrease in fat accretion and this may be due to an enhancement in GI tract health and reduction in bacterial mediated inflammation.

STAY TUNED!!!
Questions?

I am too lazy to Google the answer, so I'll just post my question on Facebook instead.