Beef Cattle Energetics

Energy transfer from feed to animals

- Gross Energy
  - Fecal energy
  - Digestible energy
  - Urinary energy
  - Metabolizable energy
  - Heat of nutrient metabolism
  - Net energy
    - Maintenance
    - Production

What is Net Energy (NE)?

Feeding experiment indicates 5000 kcal energy intake is needed to maintain weight (body energy)

\[ \text{NE} = \text{energy retained} / \text{energy intake up to maintenance} \]

\[ \text{NEG} = \text{energy retained} / \text{energy intake when energy intake exceeds maintenance} \]
Energy Reserves

- In livestock production, 0 EB is rarely achieved
  - Beef cows
    - Periods of poor forage quality/availability
      - Result in negative energy balance
        - OK to be negative as long as managed properly
    - Periods of excellent forage quality/availability
      - Results in positive energy balance
        - Important to be in positive energy balance heading into breeding season

Energy Reserves

- Important to have energy reserves
  - Optimal management of body reserves is critical for economic success of a beef cow operation

Energy Reserves

- Either extreme (excessive fat or thin) can cause
  - Metabolic problems
  - Decrease in milk production
    - Decrease in calf performance
  - Calving difficulties
  - To fat animals is a waste of resources
  - Decrease in reproductive efficiency

Energy Reserves

- Assumption is that excess energy is captured in the form of fat
  - True for animals in moderate to fat condition
  - In thinner animals, evaluating protein
Energy reserves

• Energy required for body reserves is related to the energy content of the tissues
  – NRC (1996) estimates that 5.82 Mcal are required for 1 kg of gain

Example

• 500 kg, gaining from BCS 4 to 5
  – Diet = + 3 Mcal/d

  207 Mcal (NRC Table) / 3 Mcal/d
  = 69 d for animals to gain 1 BCS (~35 kg)

Energy Reserves for BCS

Example

• 500 kg, losing condition from BCS 5 to 4
  – Diet is – 3 Mcal/d

  1 Mcal of tissue = 0.8 Mcal of diet
  – Use of body reserves is 25% more efficient than diet

  207 Mcal (NRC Table) x 0.8/ 3 Mcal/d
  = 55 d for animals to lose 1 BCS (~35 kg)

Chemical Composition

TABLE 3-5  Empty Body (EB) Chemical Composition at Different Condition Scores (CS)

<table>
<thead>
<tr>
<th>Percent in EB</th>
<th>EBW, percent of CS</th>
<th>CS</th>
<th>Fat</th>
<th>Protein</th>
<th>Ash</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>3.77</td>
<td>10.42</td>
<td>7.40</td>
<td>69.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>7.56</td>
<td>18.78</td>
<td>7.12</td>
<td>66.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>11.30</td>
<td>19.09</td>
<td>6.89</td>
<td>64.63</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>15.07</td>
<td>17.04</td>
<td>6.81</td>
<td>61.36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>18.04</td>
<td>16.75</td>
<td>5.71</td>
<td>58.70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>22.01</td>
<td>10.00</td>
<td>5.27</td>
<td>50.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>25.38</td>
<td>15.42</td>
<td>4.51</td>
<td>53.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>30.43</td>
<td>14.28</td>
<td>4.51</td>
<td>50.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>31.02</td>
<td>14.08</td>
<td>3.99</td>
<td>48.05</td>
</tr>
</tbody>
</table>

*Weight change (in lbs) can be estimated from the difference between EB weight and IB weight + percent of IB weight for the CS in question. Net energy reserves provided, or required to change CS, is kg weight change x 3.82.
Body Condition Scores

- 1 - Emaciated
- 2 - Very thin
- 3 - Thin
- 4 - Moderately thin
- 5 - Moderate (ideal)
- 6 - Moderately fleshy
- 7 - Fleshy
- 8 - Very fleshy
- 9 - Obese
BCS is a practical indicator of nutritional status and its effect on reproduction in the postpartum cow.

Short et al., 1990; Williams, 1990; Wagner et al., 1988; Randel, 1990

Prepartum Energy Balance Effects on BCS at Calving

\[ \text{BCS} = \text{EB}_{\text{pre}} (0.58 \pm 0.09) + 5.62 \pm 0.12 \quad (R^2 = 0.65) \]

Adapted from Hess et al., 2005

Relationship Between BCS at Calving and BCS at Breeding

\[ \text{BCS}_{\text{breeding}} = \text{BCS}_{\text{calving}} (0.70\pm0.06) + 1.39\pm0.30 \quad (R^2 = 0.47) \]

Adapted from Hess et al., 2005

Body Condition Score at Calving Affects Return to Estrus

\[ \text{PPI}, \text{d} = \text{BCS}_{\text{calving}} (-14.87\pm2.93) + 159.97\pm15.26 \quad (R^2 = 0.27) \]

Adapted from Hess et al., 2005

EFFECT OF BODY CONDITION SCORE (BCS) AT PARTURITION ON POSTPARTUM INTERVAL (PPI)

<table>
<thead>
<tr>
<th>BCS</th>
<th>PPI, days</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>88.5</td>
</tr>
<tr>
<td>4</td>
<td>69.7</td>
</tr>
<tr>
<td>5</td>
<td>59.4</td>
</tr>
<tr>
<td>6</td>
<td>51.7</td>
</tr>
<tr>
<td>7</td>
<td>30.6</td>
</tr>
</tbody>
</table>

Adapted from Houghton et al., Purdue University, 1990.
Effect of Postpartum Body Condition Score (BCS) Change on Pregnancy Rate

<table>
<thead>
<tr>
<th>BCS Status</th>
<th>Pregnant (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate (4.5 to 5.5) and maintaining BCS</td>
<td>100&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Thin (&lt;5) and increasing BCS</td>
<td>100&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fleshy (&gt;5) and decreasing BCS</td>
<td>94&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Thin (&lt;5) and decreasing BCS</td>
<td>69&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> Adapted from Houghton et al., Purdue University, 1990.
<sup>b,c</sup> Means with unlike superscripts differ (P < .01).

Effect of Postpartum Body Condition Score (BCS) Change on Pregnancy Rate

**Adjusting BCS**

- **NE<sub>e</sub>** Requirements, Mcal/d (1200 lb cow)
  - Mid-gestation: 8.68 (25% increase)
  - Late-gestation: 10.83 (80% increase)
  - Early Lactation (10 lb milk): 12.09
  - Early Lactation (20 lb milk): 15.18 (95% increase)

- **CP Requirements, lb/d (1200 lb cow)**
  - Mid-gestation: 1.4 (25% increase)
  - Late-gestation: 1.7
  - Early Lactation (10 lb milk): 2.1
  - Early Lactation (20 lb milk): 2.7

Energy Reserves and Reproduction

- Rapid weight gain is difficult after calving
  - especially late calving cows
  - need to reach target by calving
- Cows in good to moderate BCS
  - can lose some weight (BCS) after calving
- Thin cows at calving
  - must have ↑ postpartum E
    - Economics (sell or feed?)

Reproduction is the single most important factor associated with the economic success of the cow/calf producer.
Use Body Condition as a Wake-up Call

Feedlot Management

What is Net Energy (NE)?

Net Energy for Production

• Weight Gain
  – Lean vs. Fat
• Body Condition gain
• Fetal Growth
• Milk Production

- Feeding experiment indicates 5000 kcal energy intake is needed to maintain weight (body energy)
- NEm = energy retained/energy intake up to maintenance
- NEg = energy retained/energy intake when energy intake exceeds maintenance

- Point of Inflection IM

- Energy intake, kcal/d

- BMR

- 0 1000 2000 3000 4000 5000 6000 7000 8000

- 5000 4000 3000 2000 1000 0

- -4000 -3000 -2000 -1000 -2000 -3000 -4000
Metabolizable Protein

CP

energy (TDN)

RDP (ammonia)

MCP

RUP

Bypass

MP

Nutrient Requirements of Importance

- Energy
- Protein
- Major Minerals
- Minor Minerals and Vitamins

Feedlot Management

- Ration requirements
  - CP: 12-14%
  - Urea: 12.5 to 25% of total CP
  - P: .3%
  - K: .7%
  - Ca: .6%
  - Vit. A: 40,000 IU
  - Vit. E: 20,000 IU

The Normal Growth Curve

Management for more rapid growth changes the shape

Adjustments to Requirements (feedlot)

- Frame size
- Implants
- Feed additives
- Step up programs
- Bunk Management/monitoring
Weight at 28% Body Fat

<table>
<thead>
<tr>
<th>Frame Size</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steer</td>
<td>882</td>
<td>954</td>
<td>1029</td>
<td>1102</td>
<td>1175</td>
<td>1250</td>
<td>1322</td>
<td>1395</td>
<td>1470</td>
</tr>
<tr>
<td>Heifer</td>
<td>705</td>
<td>763</td>
<td>824</td>
<td>882</td>
<td>939</td>
<td>1001</td>
<td>1058</td>
<td>1115</td>
<td>1177</td>
</tr>
</tbody>
</table>

Feedlot Management

• Matching Feeding Programs to Cattle types
  – Cattle age
  – Weight
  – Condition
  • Previous growth rate and plane of nutrition

Feedlot Management

• Low previous plane of nutrition
  – Skeletal growth
  – Condition
  – Capacity
  – Compensatory gain

Feedlot Management

• Feeding Program
  – Immediate finish programs
    • Gradual step up
    • Length of feeding periods
      – Calves
      – Yearlings
      – 2 yr olds
    • Best suited for
      – Fleshy cattle
      – Large framed cattle
      – Older, heavier cattle
      – Operations with large amounts of grain

Feedlot Management

• Deferred finishing program
  – Growth phase
    • Time
    • ADG
    • Ration
    • Backgrounding or stocker
    • Pasture feeding program

Feedlot Management

• Bunk Management
  – Methods of increasing gain
    • Stair-step
  – Intake
    • Weather
    • Feeding frequency
Developing a Starting Program

• determine expected intake
• determine eventual ration
• determine beginning concentrate levels

Feedlot Management

• Ration step-up

<table>
<thead>
<tr>
<th>Forage:Concentrate</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>50:50</td>
<td>5</td>
</tr>
<tr>
<td>40:60</td>
<td>5</td>
</tr>
<tr>
<td>30:70</td>
<td>5</td>
</tr>
<tr>
<td>20:80</td>
<td>5</td>
</tr>
<tr>
<td>15:85</td>
<td>5</td>
</tr>
<tr>
<td>10:90</td>
<td>5</td>
</tr>
</tbody>
</table>

Sample starting program - yearlings (800 lb.)

<table>
<thead>
<tr>
<th>Conc., lb</th>
<th>Feed Intake</th>
<th>% Conc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>Week 2</td>
<td>10</td>
<td>17</td>
</tr>
<tr>
<td>Week 3</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>Week 4</td>
<td>17</td>
<td>23</td>
</tr>
<tr>
<td>Final ration</td>
<td>20</td>
<td>25</td>
</tr>
</tbody>
</table>

Adapting cattle to grain

• Two parts
  – Manage feed consumption
  – Adjust rumen microbes to new substrate
  – Each may take 2-3 weeks with calves
  – May only take 4 weeks with previously adapted yearlings
• Thumb rule for initial grain consumption
  – .5 to 1% of bodyweight

Making Feed Calls

• Cattle Aggressiveness
• Weather
  – Heat
  – Mud
  – Rain
  – Cold
• Storm Rations?

Other Bunk Mgmt Factors

• Feed presentation
  – Mixing
  – Processing (particle size)
  – Fines (conditioners)
  • Molasses
  • Fat
  • Nutritional Adequacy
Feedlot Management

- Bunk reading
  - Rules
    - Empty bunks
    - Stale feed
    - Moving cattle
    - Mixing properly
    - Even distribution
    - Hot weather
    - Barometer

Goal of Feedbunk Management

- Deliver a consistent, nutritious, fresh ration in a manner that maximizes feed intake and minimizes waste and spoilage.

Some Items a Good Bunk Sheet Should Contain

- Pen Number
- Lot Number
- Head Count
- In Weight
- Current Weight
- Days on Feed
- Days on Ration
- Indication of Slick Bunks
- Indication of When Bunks Last Cleaned
- Amount of Feed Fed Last 5-7 Days

From Horton (1990)

SDSU Bunk Scoring System

- Developed to improve feed deliveries in a University Research Feedlot
- Improved efficiency
- Uses a 4-Point Bunk Scoring System

From Pritchard (1993)

SDSU 4-Point Bunk Scoring System

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No feed remaining in bunk.</td>
</tr>
<tr>
<td>1/2</td>
<td>Scattered feed present. Most of bottom of bunk exposed.</td>
</tr>
<tr>
<td>1</td>
<td>Thin uniform layer of feed across bottom of bunk. Typically about 1 kernal deep.</td>
</tr>
<tr>
<td>2</td>
<td>25-50% of previous feed remaining.</td>
</tr>
<tr>
<td>3</td>
<td>Crown of feed is thoroughly disturbed. &gt;50% of feed remaining.</td>
</tr>
<tr>
<td>4</td>
<td>Feed is virtually untouched. Crown of feed still noticeable.</td>
</tr>
</tbody>
</table>

Bunk Score 0 to 1/2
Feedlot Management

- Feed efficiency is critical
  - Affected by
    - E density
    - Grain processing
    - Feed additives
    - Implants
    - Wt of cattle
      - Fat gain
      - Protein gain
    - Environmental stress
    - Scales

Feedlot Management

- A 5% increase in G:F results in
  - Decrease in ration cost
  - Increase in ADG
  - Increase in ADG, usually results in a
    increase in G:F

Feed Additives

- MGA
  - Heifers
    - Eliminate estrus activity
    - Increase ADG
- Implants
  - Increase ADG, G:F
- Antibiotics
- Ionophores

Feed Additives for Feedlot Cattle

- Ionophores
- MGA
- Optaflexx
- Broad spectrum antibiotics
- Coccidiostats
Feedlot Management

- Economic impact of 140 d feeding period
  - 2 implants +$14.14/hd
  - Ionophore +$17.40/hd
  - 1 implant + ionophore +$31.54/hd
  - Implant cost -$3.00/hd
  - Ionophore cost -$3.00/hd

  +$25.54/hd