Dry Matter Intake & Carbohydrates

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The New Dairy “NRC”

- Seven years in the making
- Now is NASEM: National Academies of Science, Engineering, and Medicine
- Previewed at an ADSA Discover Conference 8/30-9/2
- Official release: December 2021
Committee

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Chapters 480 pages (380 in 2001)

- Defining Requirements*
- Dry matter intake*
- Energy
- Fat
- Carbohydrates*
- Protein*
- Minerals
- Vitamins
- Water
- Nutrient requirements of the young calf
- Growth
- Dry and transition cows

- Dairy production systems
- Dairy cattle nutrition and the environment
- Feed by-products
- Feed additives
- Agents that are toxic to dairy cattle
- Feed analysis*
- Nutrient composition of feeds
- Model description and evaluation
- Nutrient requirement tables
Dry Matter Intake

Many factors affect intake
- Physical limitations
- Metabolic control
- Interaction of diet and physiological state
- Integration of signals

New Equations
- Animal factors: milk energy, BW, BCS, DIM
- Filling effects of diets
- Most accurate when both are considered
Dry Matter Intake

DMI (kg/d) = [3.7 + Parity x 5.7] + 0.305 x MilkE (Mcal/d) + 0.22 x BW (kg) + (−0.689 −1.87 x Parity) x BCS] x [1 − (0.212 + Parity x 0.136)] x e^{(-0.053 x DIM)}

DMI (kg/d) = 12.0 − 0.107 x fNDF + 8.17 x ADF/NDF + 0.0253 x fNDFD − 0.328 x (ADF/NDF − 0.602) x (fNDFD − 48.3) + 0.225 x MY + 0.00390 x (fNDFD − 48.3) x (MY − 33.1)

DMI Models with only animal factors over-predicted at high DMI, and underpredicted at low DMI.

Allen et al., 2019. J. Dairy Sci. 102:7961
Dry Matter Intake

- uNDF240 to predict DMI?
  - uNDF240 alone is not limiting
  - Relationship varies.

In vitro uNDF240 with second inoculation at 120 h.
- Use Animal estimate
- Enter ration
- Use Animal/Fiber estimate
Carbohydrates

- 70 to 80% of diet dry matter.
- Main source of volatile fatty acids (VFA) that can provide up to 70% of energy needs.
- Essential for microbial protein production.
Carbohydrates

- 70 to 80% of diet dry matter.
- Main source of volatile fatty acids (VFA) that can provide up to 70% of energy needs.
- Essential for microbial protein production.
Only NonFiber Carbohydrates (NFC) by difference and Neutral Detergent Fiber (NDF) were considered. Lignin or 48 h NDF in vitro digestibility was used to estimate digestibility of NDF.

9 pages
Neutral Detergent-Soluble Carbohydrates (NDSC)
- Starch
- Water-soluble carbohydrates (WSC)
- Neutral detergent-soluble fiber

Residual organic matter
Neutral detergent fiber (NDF)
- Forage and nonforage
- Lignin

Carbohydrate digestibility
Physically effective & physically adjusted NDF*
Carbohydrates

NDF, WSC, & NDSF: carbohydrates based on solubility.

NDSC ≠ NFC
No organic acids, by analysis, not by difference.

Recommended methods are in the Feed Analysis chapter. TSI ok for WSC.
Discussion of research findings on digestibility and ruminal impact.

**Mostly on starch**…which has the most data.*

-- Moderate substitution sugars for starch: little effect on pH.
-- Based on in vitro rates: WSC&NDSF largely digested ruminally.
-- Ruminal digestibility of starch: variable and affected by processing, grain type, conservation method, ration composition….
-- Ruminal starch products affected by starch/forage amount.
-- NDSC fermentations differ in which VFA predominate.
Recommendations

Need to be based on published data.

Committee worked with what was available.
NDSC

Recommendations on formulation with NDSC?

To give specific feeding recommendations on the different NDSC, we need more research data across more varied diets with WSC, starch, and NDSF composition, particle size, etc. reported for diets and feeds.
Residual Organic Matter (ROM)

= dry matter – ash – crude protein – NDF - fatty acids – starch

Used to calculate energy values.
Includes WSC, NDSF, organic acids, glycerol, components not in analyzed feed fractions, and analytical error.
Need more data to assess if there’s need to improve.
NDF

Discussion on research findings, primarily on rumen function and estimating digestion.

Ruminal NDF fermentation is affected by
- NDF composition -- lignin
- physical form – forage vs. nonforage
- pH
- retention time
- fragility
- rate of fermentation
- RDP(?)
- Entire diet
- …
Predicting Carbohydrate Digestion

- **Tables**: Utility? Values are too variable.

- **Single in vitro time points**:
  - Provide important relative information.
  - In vivo digestibility affected by many more factors.
  - For NDF: May not equal in vivo, but 48 h* was correlated with intake and milk yield.

- **Digestion & Passage**: No values for passage of nutrient fractions of individual feeds.

- **Use the measures to which your equations / model are calibrated.**
Physically Effective NDF

Physical form affects the rumen environment:
- Enhance rumination
- Allow ruminal retention
- Maintain desirable rumen pH
- Forage has greater impact than nonforage NDF.
- Research focus.

Balchem Podcast, 9/8/2021
Approach 1: Forage NDF

Formulate for forage NDF relative to dietary starch content.

<table>
<thead>
<tr>
<th>Minimum fNDF</th>
<th>Minimum total</th>
<th>Maximum starch</th>
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<tbody>
<tr>
<td>19</td>
<td>25</td>
<td>30</td>
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<td>15</td>
<td>33</td>
<td>22</td>
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</tbody>
</table>
Approach 1: Forage NDF Adjustments.

Optimal diet forage NDF concentration

<table>
<thead>
<tr>
<th>15</th>
<th>25</th>
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<tbody>
<tr>
<td>15</td>
<td>&lt;- Higher dry matter intake</td>
</tr>
<tr>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Faster ruminal clearance rate of forage NDF -&gt;</td>
<td></td>
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<tr>
<td>Finely chopped forages -&gt;</td>
<td></td>
</tr>
<tr>
<td>Higher diet starch, lower NFFS concentrations -&gt;</td>
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<tr>
<td>Higher diet starch degradability -&gt;</td>
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<tr>
<td>&lt;- Supplemental buffers</td>
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<tr>
<td>Grain fed separately, infrequently -&gt;</td>
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<tr>
<td>Limited feed bunk space, slug feeding -&gt;</td>
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<tr>
<td>Greater daily variation in diet composition -&gt;</td>
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</table>
Approach 2: Physically Adjusted NDF (paNDF)

- Developed to give guidance on desired TMR particle size measurable on farm.
- Identified factors that affected the need for or effectiveness of fiber.
- The target ruminal pH (6.0-6.1) is a proxy for a desirable rumen environment, not a prediction.
- Derived from 60 publications that had 241 treatment means and used an ensemble model approach.

White et al. 2017. JDS 100:9551
White et al., 2017 JDS 100:9569
Approach 2: Physically Adjusted NDF (paNDF)

**Inputs:**
- Diet characteristics, % of dry matter
  - Forage NDF, total forage, wet forage
  - Cottonseed: whole, hulls, meal
  - NDF, ADF, CP, starch
- Body weight
- Penn State Particle Separator (PSPS)
  - % of TMR DM on 19 mm sieve (1.18 optional)

**Output predictions:**
- Recommended % of TMR DM on 8 mm sieve
- Minutes per day of rumination
Approach 2: Physically Adjusted NDF (paNDF)

No dataset has *complete or balanced* coverage of all key independent variables.

**Ensemble Model Approach**

- Technique that takes a core concept (i.e. rumen pH) and converts it into a “*constellation*” of models.
- Integrates equations with weighting factors over a range of conditions will be better at “future prediction”.
- Particularly useful where minimal data or that from diverse research studies are available for equation development.
Approach 2: Physically Adjusted NDF (paNDF)

Ensemble models aggregate predictions from multiple different models to yield a mean and range of responses.

Compared to individual models, gives more reliable predictions of events, confidence intervals, and is less likely to generate systematic errors.

White et al. 2017. JDS 100:9551
paNDF

Ensemble model:

**Fixed factors, % of DM:**
- Starch: 15-32.5%
- ForageNDF: 10-30%
- on 19 mm sieve: 6-18%

**Response, % of DM:**
- on 8 mm sieve.
- Black line is prediction, gray is min/max range of prediction.
Approach 2: Physically Adjusted NDF (paNDF)

Not feasible to give tables or equations of all possible permutations.

paNDF app available free of charge at Google Play and App Store: “Munch for Dairy Cows”
Questions?

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