Dry Matter Intake & Carbohydrates

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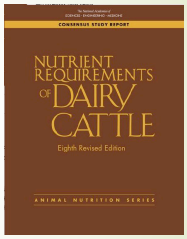
The New Dairy "NRC"

- 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



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Committee

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SARAH KWON, Senior Program Assistant

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Chapters 500+ 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

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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

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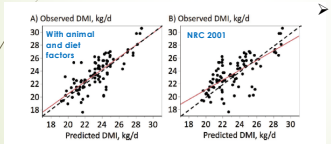
Dry Matter Intake

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 $e^{(-0.053 \times DIM)}$]

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

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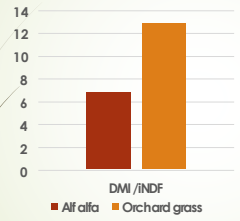
Dry Matter Intake



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

In vitro uNDF240 with second inoculation at 120 h.
Kammes and Allen, 2012. J. Dairy Sci. 95:3288

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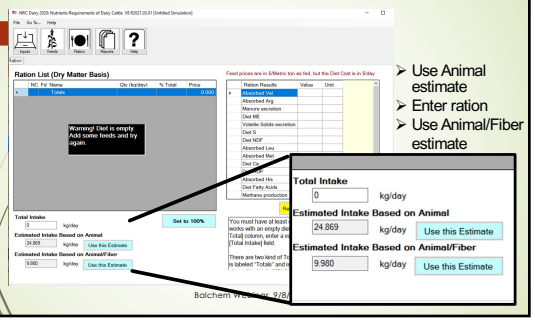

- Use Animal estimate
- Enter ration
- Use Animal/Fiber estimate

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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.

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Dairy NRC, 2001

TABLE 4-3 Recommended Minimum Concentrations (% of DM) of Total and Forage NDF and Recommended Maximum Concentrations (% of DM) of NFC for Diets of Lactating Cows When the Diet is Fed as a Total Mixed Ration, the Forage has Adequate Particle Size, and Ground Corn is the Predominant Starch Source[a]

Minimum forage NDF[b]	Minimum dietary NDF[c]	Maximum dietary NFC[d]	Minimum dietary ADF[e]
19[f]	25[f]	44[f]	17[f]
18	27	42	18
17	29	40	19
16	31	38	20
15[f]	33	36	21

[a]Values in this table are based on the assumption that actual feed composition has been measured; values may not be appropriate when values from feed tables are used.
[b]All feeds that contain substantial amounts of vegetative matter are considered forage. For example, corn silage is considered a forage, although it contains significant amounts of grain.
[c]Nonfiber carbohydrate is calculated by difference 100 - (%NDF + %CP + %Fat + %Ash).
[d]Minimum dietary ADF recommendations were calculated from NDF conversions. (See text)
[e]Diets that contain less fiber (forage NDF, total NDF or total ADF) than these minimum values and more NFC than 44 percent should not be fed.

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

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8th Revised Edition (12 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*

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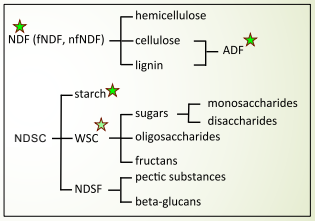
Carbohydrates

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.



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NDSC

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.

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Recommendations

Need to be based on published data.

Committee worked with what was available.

Courtesy of Ken Nordlund

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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.

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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.

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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
- …

P. J. Van Soest
1929 - 2021

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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.**

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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.

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Approach 1: Forage NDF

Formulate for forage NDF relative to dietary starch content.

Minimum fNDF	Minimum total NDF	Maximum starch
19	25	30
18	27	28
17	29	26
16	31	24
15	33	22

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Approach 1: Forage NDF Adjustments.

Optimal diet forage NDF concentration

15 <- Higher dry matter intake 25

Faster ruminal clearance rate of forage NDF ->

Finely chopped forages ->

Higher diet starch, lower NFFS concentrations ->

Higher diet starch degradability ->

<- Supplemental buffers

Grain fed separately, infrequently ->

Limited feed bunk space, slug feeding ->

Greater daily variation in diet composition ->

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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

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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

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Approach 2: Physically Adjusted NDF (paNDF)

No dataset has *complete or balanced c*overage 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.

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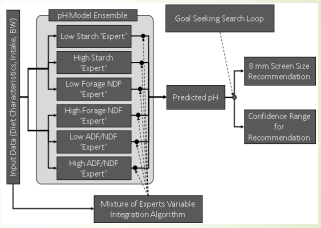
Approach 2: Physically Adjusted NDF (paNDF)

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

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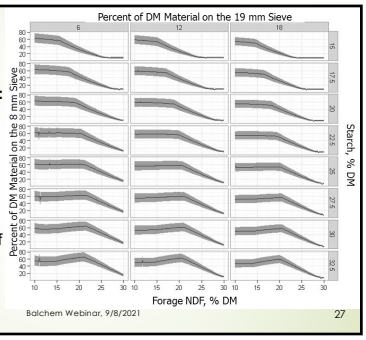
paNDF

Ensemble model:
Fixed factors, % of DM:
Starch: 15-32.5%
ForageNDF:10-30%
on19 mm sieve: 6-18%

Response, % of DM:
on 8 mm sieve.
Black line is prediction, gray is min/max range of prediction.



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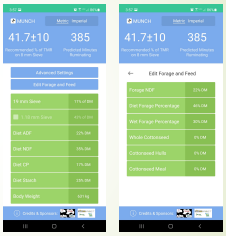
Approach 2: Physically Adjusted NDF (paNDF)

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"



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Questions?

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