On-Farm NIR Analyses and Its Role in Precision Feeding

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Why the interest in precise feeding and on-farm analysis?

Why Precise Feeding Is Important

- Profit margins for milk production are narrow
- Milk production per cow has increased to the point that accurate rations are necessary
- Excretion of excess nutrients is unacceptable

Objectives

- Describe why precise feeding is important for dairy cows
- Define the differences between feed formulation and feed mixing
  - Explain how feed analysis is used for each
  - Describe the role of forage dry matter (DM) in feeding dairy cows
- Explain why DM is difficult to measure
- Present results of on-farm analysis experiments

Why do we need to feed cows precisely every day?

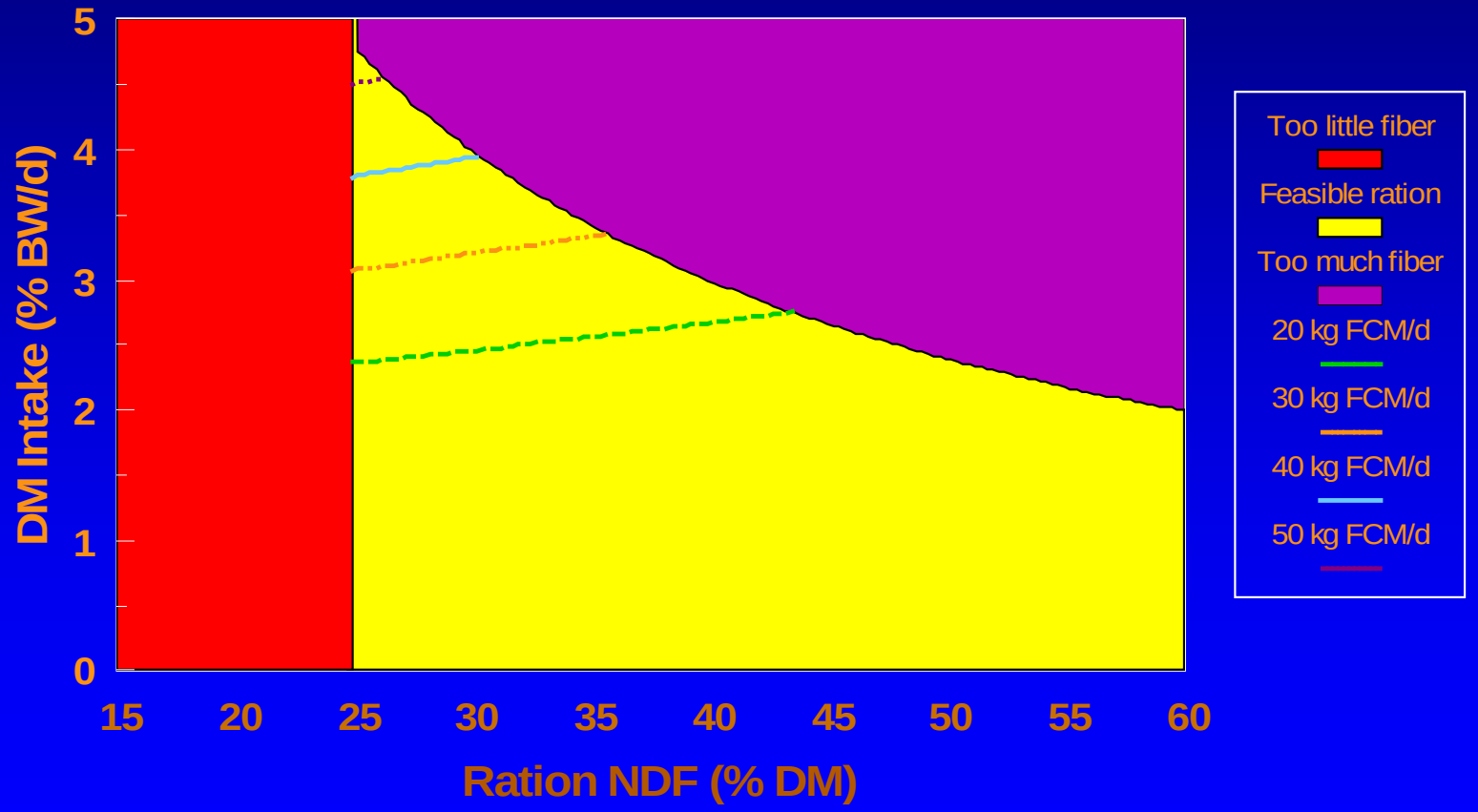
- Lactation has the greatest nutrient demand of any animal production
  - Maintenance nutrient demand is that required to keep the animal alive
    - Cows typically chew more than 10 h/day!
  - Milk production can easily be 3-5 times the energy demand for maintaining the cow
  - Growth and fattening is only 1-2 times the maintenance requirement
  - Activity is typically less than 1 times maintenance needs

Why do we need to feed cows precisely every day?

- High producing cows are fed a very narrow range in diets
  - High milk production requires high protein and energy density in the ration
    - Obtained from grains and protein meals
    - Highly digestible, low fiber feeds
  - But dairy cows are ruminants that have a minimum fiber requirement
    - Obtained from forages (hays, silages, pasture)
    - Incompletely digested, high fiber feeds

NDF-Energy Intake System

Ration options decrease as milk production increases



Why do we need to feed cows precisely every day?

- Difficult to over-formulate rations like we did in the past
  - Increases feed costs and reduces profit
  - Can't maintain balance of nutrients in rations for high production
    - Putting in one nutrient in excess requires the removal of another required nutrient
  - Environmental concerns related to excess nutrient excretion

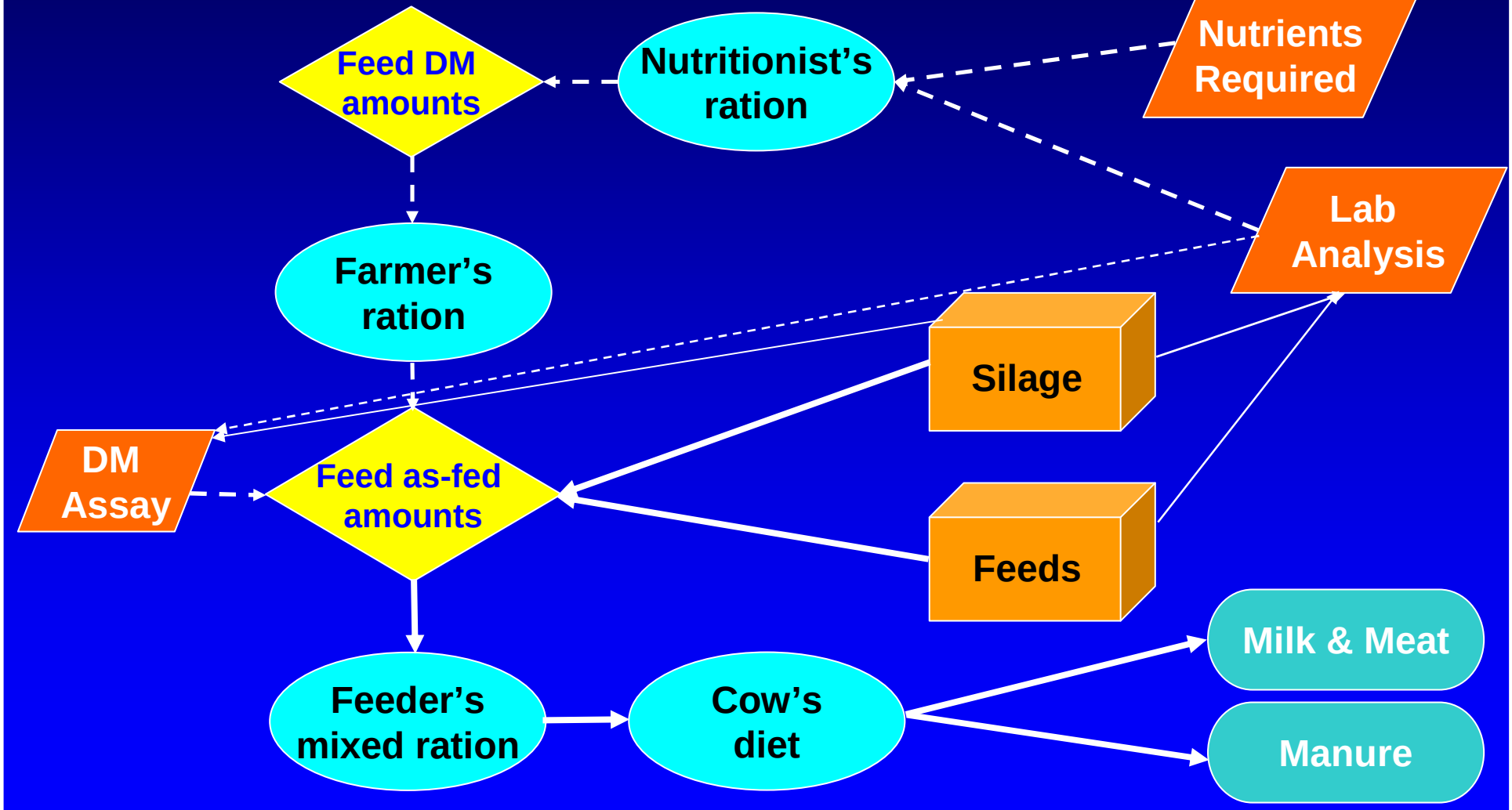
How do we feed cows precisely every day?

- Minimize daily variation in the ration
  - Feed multiple ingredients in rations
    - Unlikely that all ingredients will vary in the same direction on a given day
  - Select feeds that have lower variability (corn silage)
- Adjust rations daily for variation in feeds
  - Place for on-farm analysis
  - Most important for simple rations (4-5 ingredients) containing variable feeds (alfalfa silage)

How do we feed cows precisely every day?

- How may rations are there on the farm for a particular group of cows?

Cycle of Feeding
What ration is the cow really getting?



Differences in Feed Formulation and Feed Mixing

- Feed formulation
  - Performed by a nutritionist
  - Matches dry feed amounts to nutrient requirements of animals
  - Uses laboratory feed analysis of numerous nutrients and National Research Council (NRC) tables of nutrient requirements
- Feed mixing (feeding)
  - Performed by someone on the farm
  - Must convert dry matter (DM) amounts into amounts of as-fed or as-is feeds

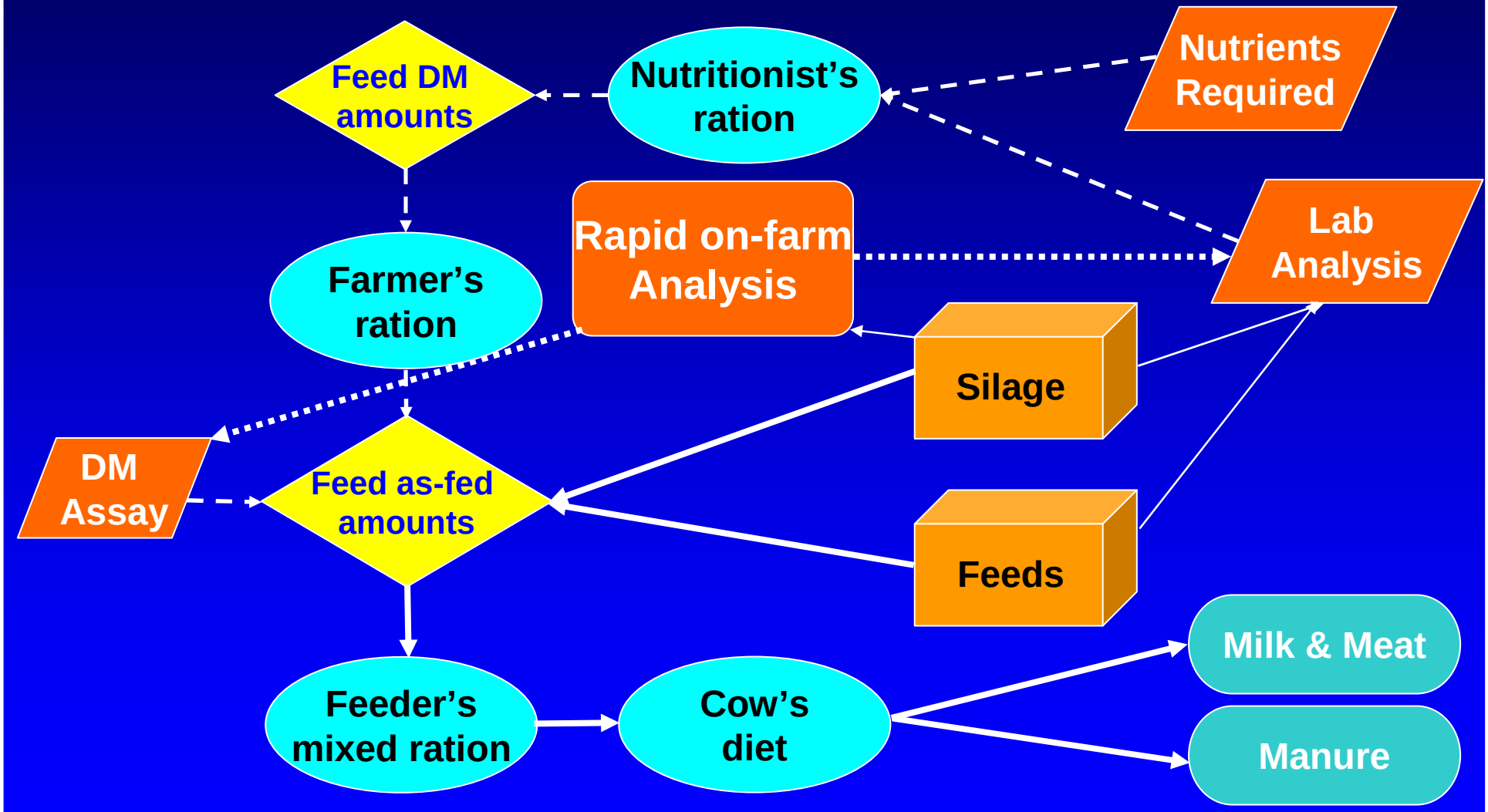
Why are Rations Formulated on a DM basis?

- Nutritionists determine the amounts of dry feed needed in the ration because only the dry matter contains nutrients
- Water (moisture or DM) content of feeds is variable
- Water is simply a diluent in feeds
  - Animals don't care if the water is in the feed or in the water trough
  - But water dilutes the nutrient concentration in feeds

Why are Rations Mixed on an as-is or as-fed basis?

- Water is a part of the feed weight
  - 100 lb of grain = 90 lb of dry feed + 10 lb of water
  - 100 lb of silage = 40 lb of dry silage + 60 lb of water (40% DM)
- What happens if DM decrease (moisture increases) in silage?
  - 100 lb of silage = 30 lb of dry silage + 70 lb of water (30% DM)

Cycle of Feeding
Where Does On-Farm Analysis Fit?



Value of On-Farm Analyses

- What is the value?
  - Is there inherent value in analytical results?
- Where is the value?
  - What analyses have immediate value?
  - Where is the variation in analyses?
- Why is it valuable?
  - Does it increase capabilities or automate processes?
  - Does it save feed costs?
  - Does it increase animal production?
  - Does it reduce problems?

DM is Simple to Define, but Difficult to Measure Routinely

- Ideal Definition = DM is the material left after water (moisture) is removed
- Measuring water in feeds is complicated
- Water has many forms
  - Surface water (dew, rain, snow, added)
  - Intercellular water (inside cells of feeds)
  - Intermolecular water (tied to chemical molecules)
- Water can be measured by distillation or by chemical reaction (Karl Fischer method)
  - Slow, tedious, and small samples (KF)

DM is Simple to Define, but Difficult to Measure Routinely

- Oven-drying (the reference method of choice) does NOT measure true moisture or DM
  - Measures “loss on drying”
- Volatile compounds other than water also evaporate in ovens
  - Ammonia
  - Alcohols
  - Volatile fatty acids
  - Organic acids
  - Urea, bicarbonate, simple sugars?
- Fermented feeds like silages can contain significant concentrations of volatiles

DM is Simple to Define, but Difficult to Measure Routinely

- Calibration of NIRS based on oven DM determination is complicated by
  - Time, temperature and air flow during oven drying
    - Types of water
    - Losses of volatile matter
  - Variation in particle size of chopped material
  - Presentation of the material to the sensor
  - Temperature of the feed
    - Frozen silages

Research using On-Farm NIRS

- Conducted at the U.S. Dairy Forage Research Center (USDFRC), Madison, WI
- Obtained a prototype sensor (HarvestLab™) from Deere & Co
  - (disclaimer)
- Developed in-house calibrations based on USDFRC DM determinations on alfalfa silage, corn silage and total mixed rations (TMR)

John Deere HarvestLab™ Benchtop On-Farm Application

Research using On-Farm NIRS

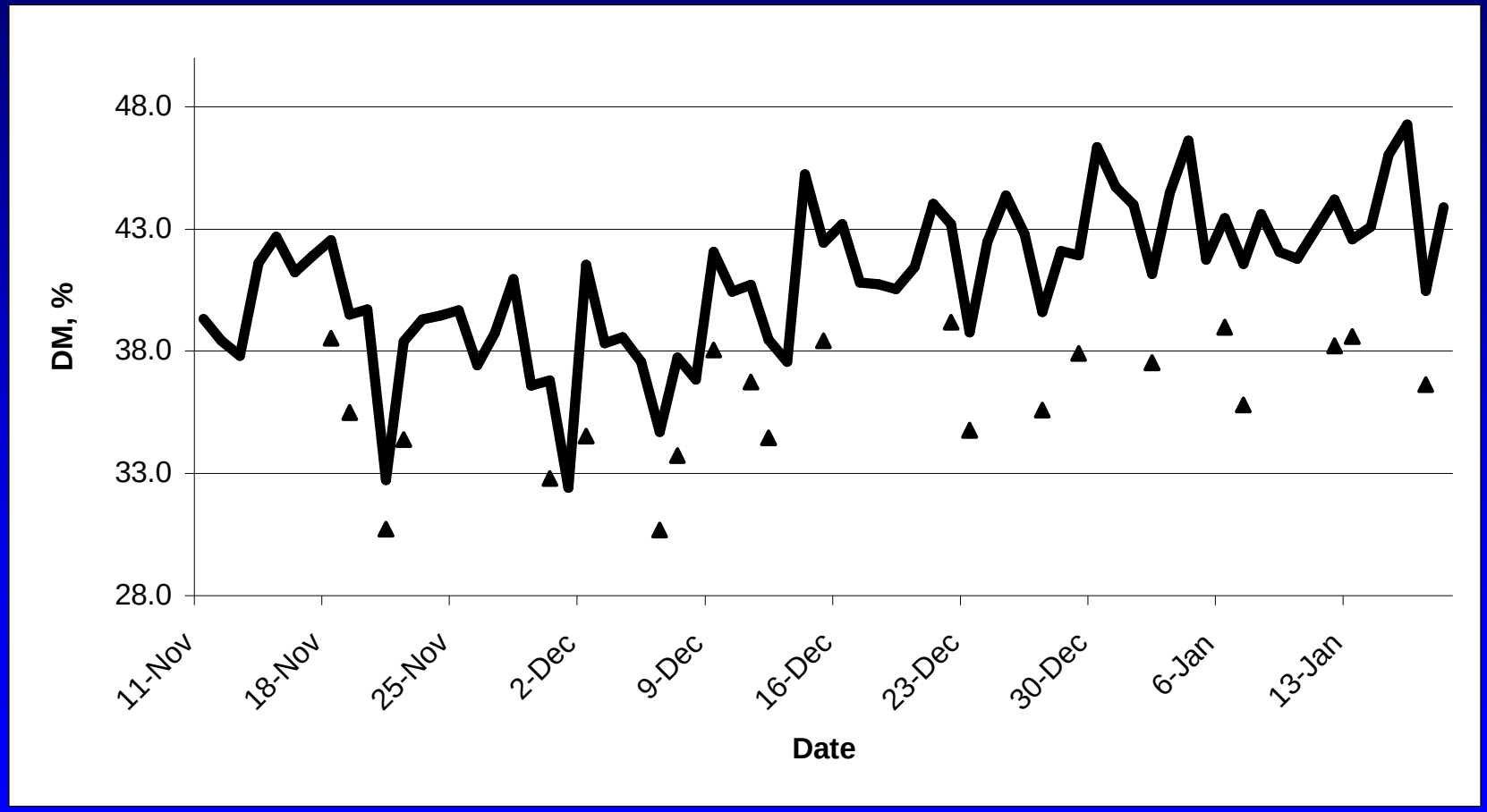
- Objectives:
  - Determine the variation due to sample collection technique at the silo and sub-sampling of material for on-farm analysis
  - Quantify the variation in forage DM with daily sampling using the on-farm NIRS
  - Evaluate the effects of changing forage DM on ration imprecision and dairy cow performance

Research using On-Farm NIRS

- Materials and Methods
  - Alfalfa silage was first-cutting that was harvested over five days from 10 fields planted with five varieties
  - Corn silage was harvested over three days from two fields that were each planted with a single, but different hybrid
  - Silages were stored in bunk silo with plastic cover and occurrences of rain or snow were recorded
  - Silages were sampled daily for about two months (mid November 07 to mid January 08)
    - Fed and sampled from defaced silage each day
    - Each morning two samples were collected from each silo after material was defaced for the daily feeding
    - Each sample consisted of 5 to 7 handfuls from separate locations in the defaced silage

Research using On-Farm NIRS

- Variation in alfalfa silage

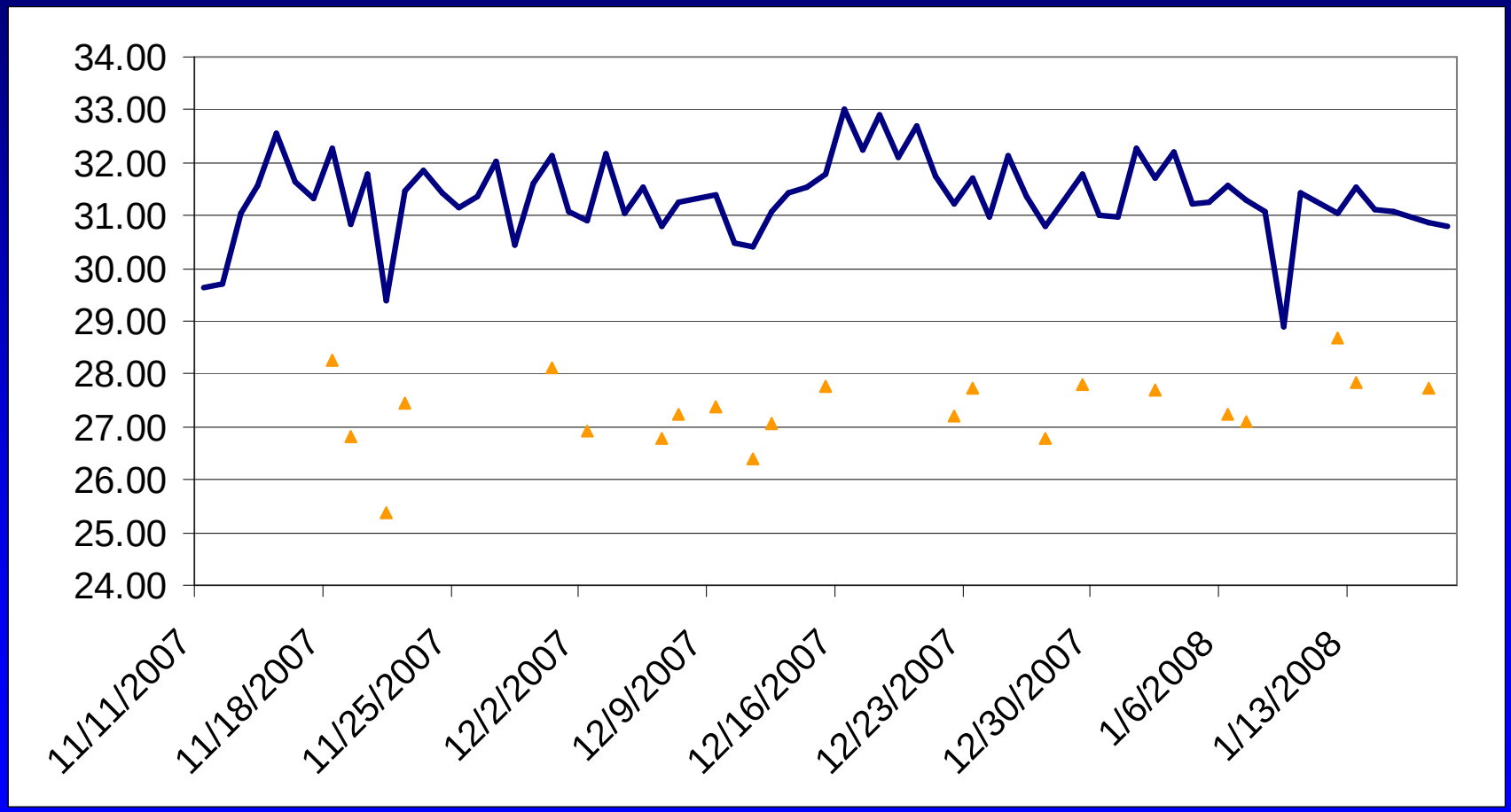


Research using On-Farm NIRS

- Results
  - Of the two silages, alfalfa was the most variable with DM content that varied between 32.4 and 47.0%
  - Corn silage had much less variation than alfalfa silage ranging from 28.9 to 33.0%

Research using On-Farm NIRS

- Variation in corn silage



Research using On-Farm NIRS

- During 68 days of sampling
  - 22 rain or snow events were recorded
    - 14 changes in DM differed by more than 3.6 percentage units (±1.2 SD) from the previous day
    - 4 of these changes were associated with precipitation events that lowered DM percentage by an average of 5.6 percentage units
    - The largest daily change in DM observed was 8.6 percentage units

Research using On-Farm NIRS

- Most of the variation was due to sample differences among days
  - Each day is an independent estimate of the silage DM
  - This variation is due to random sample differences that do not affect the cow
  - 25% of the changes in DM would warrant a change in the ration
  - 10% of the changes were large and due to rain or snow events
  - There was a gradual increasing trend in alfalfa silage DM suggesting that the silage was changing

Research using On-Farm NIRS

- Materials and Methods – Cow Trials
  - Forty eight cows were assigned to either a control (CON) or treatment (TRT) group
  - TRT consisted of changing forage DM to simulate a rain event on a bunker silo and feeding an imprecise ration based on as-fed ratios of ingredients
  - CON ration was adjusted to maintain DM ratios of ingredients on that day
  - Each period consisted of three days for baseline, one day (d4) with ration differences, and three days of recovery
  - Ration changes were repeated 5 times by changing DM of corn silage or alfalfa silage or both by 8%-units.

Research using On-Farm NIRS

- Results – Cow Trials
  - DM intake of TRT was reduced on d4 (-2.2 kg) compared to the baseline, but cows returned to baseline intakes during recovery
  - Compared to baseline, milk production, but not composition, of TRT was affected in the two days following d4 (-0.86 kg/d) compared to an increase of 0.43 kg/d by the CON group
  - Conclude that improving ration precision by adjusting rations for forage changes in DM enhances DMI and milk production

Is there value in on-farm analysis?

- It depends!
  - Production level of the cows
  - Closeness of rations to requirements
  - Variation in the forages
  - Complexity of the ration
  - Intensity of environmental concerns
  - Value of milk relative to feed

Precise Feeding of Dairy Cows
Value of On-Farm Analyses

Questions and Discussion

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