



# Defining Quality in Alfalfa (Deconstructing the Plant)

---

David C. Weakley, Ph.D.

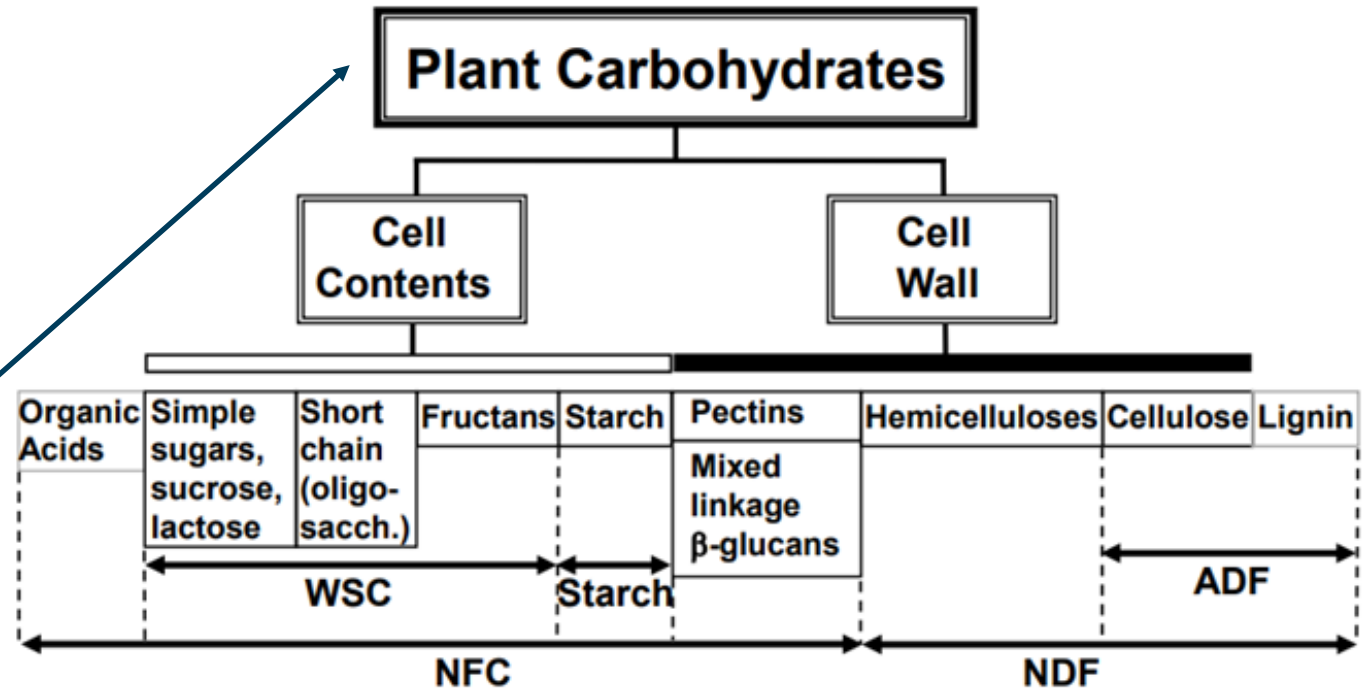
Director, Dairy Forage Nutrition Research

Forage Genetics International

# Introduction

- Crude Protein (CP) +
- Ash +
- Fat +
- Fibrous Carbohydrates (Neutral Detergent Fiber; NDF) +
- non-Fibrous Carbohydrates (NFC)

= **100%** (DM Basis)



Hall, 2015



# Sample Analysis

- ④ 1070 samples of freshly cut alfalfa plants
- ④ Hand-harvested from test plots in WI, CA, WA, ID, KS, PA, IA, and Argentina from 2019-2022
  - ④ Chosen to represent standing plants
  - ④ Procured across multiple cuttings, fall dormancies and maturities
- ④ Analyzed for CP, Ash, Fat, Neutral Detergent Fiber (NDF), NDF Digestibility (NDFd48hr), and Starch.



# Crude Protein (CP)

☼ Highest CP containing forage

☼  $22.8\% \pm 3.2$  (wide variation)

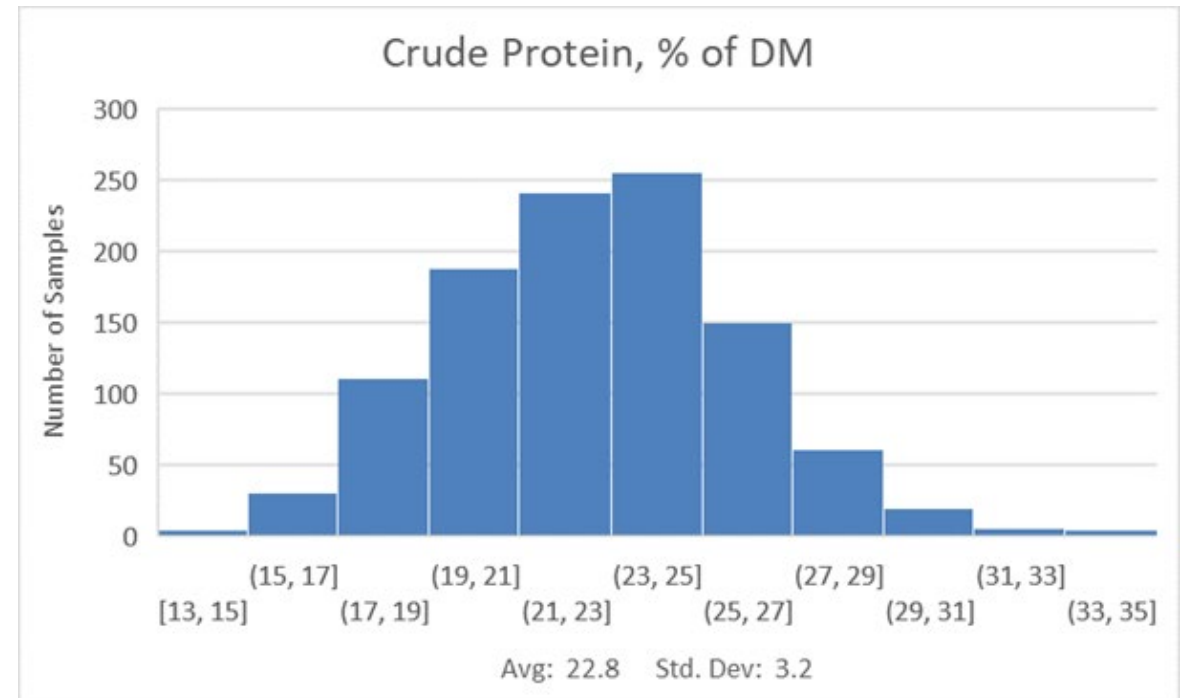
☼ Contributes to Metabolizable Protein (MP) supply

☼ Approximately 24% Rumen Undegraded Protein (RUP)

☼ Approximately 76% Rumen Degraded Protein (RDP)

☼ RDP contains peptides and amino acids → microbial protein synthesis (MCP)

☼ RUP + MCP → MP supply



FGI, 2022

# Alfalfa Influences Milk Components

- ④ 105 high producing dairy cows fed 62% forage diets.
  - ④ 5 different ratios of alfalfa hay to corn silage in the forage mix
  - ④ Similar nutrient and energy content
- ④ Diet between 30:70 and 50:50 was optimum.
  - ④ higher milk protein yields,
  - ④ lower MUN level (milk urea nitrogen, a reflection of rumen ammonia levels)
  - ④ higher de novo FA levels (a reflection of milk fatty acid synthesis)
- ④ Presumably due to improved ruminal microbial growth and protein synthetic activity.

## Milk components

	Alfalfa-to-corn silage ratio (DM basis)				
	10:90	30:70	50:50	70:30	90:10
Fat, %	4.08	4.06	4.02	4.01	4.22
Fat, lb/d	3.9	4.0	4.0	3.9	4.0
True protein, %	3.01	3.07	3.01	3.02	3.05
True protein, lb/d <sup>a</sup>	2.93	3.02	3.00	2.90	2.92
MUN, mg/dl <sup>b</sup>	9.8	8.5	10.4	11.0	12.0
De novo FA, g/100 g FA <sup>b</sup>	24.76	25.86	25.82	25.22	25.58

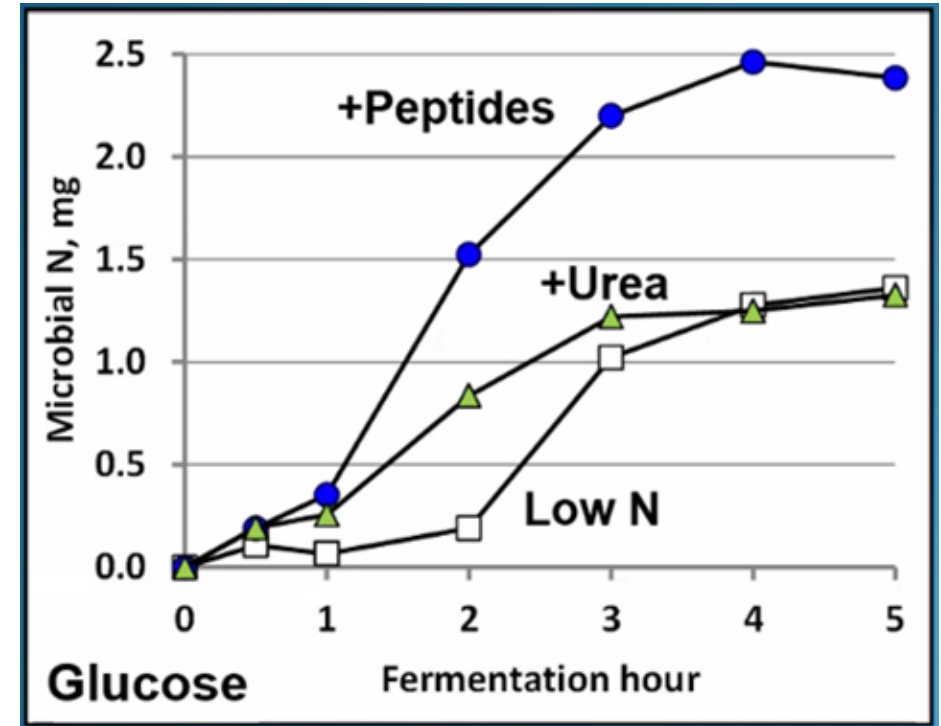
<sup>a</sup>Significant cubic effect ( $P < 0.05$ ).

<sup>b</sup>Significant quadratic effect ( $P < 0.05$ ).

Grant et al., 2022

# Peptides enhance microbial nitrogen synthesis

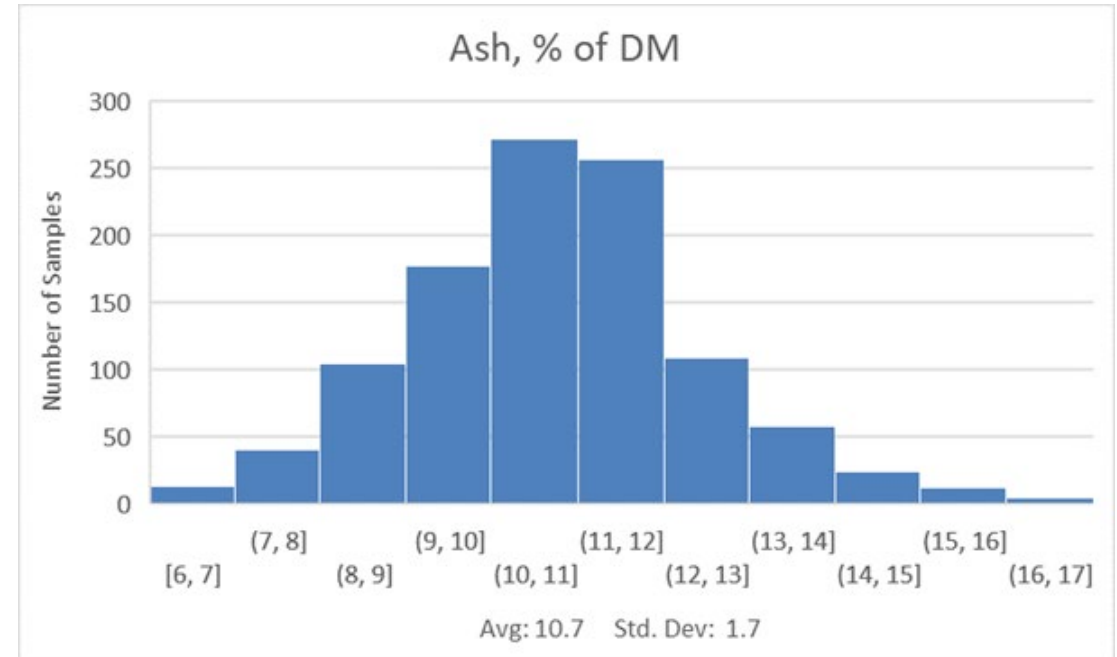
- ⊕ Peptides supported greater microbial protein nitrogen synthesis than did urea when supplemented *in vitro*
- ⊕ The RDP in alfalfa has been shown to be a rich source of peptides, derived primarily from Ribulose-1,5-bisphosphate Carboxylase (Rubisco) (Howarth et al., 1977)
- ⊕ Suggests alfalfa RDP could stimulate microbial yield in the rumen



Hall, 2017

# Ash

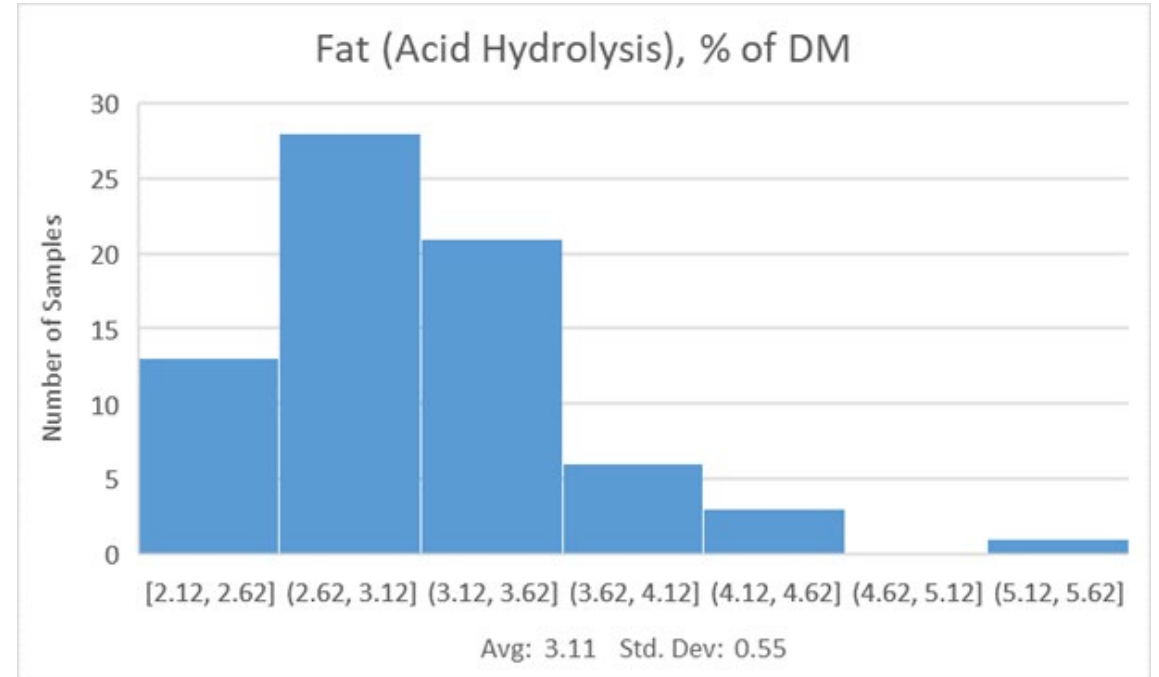
- ④ Average ash content was 10.7%
  - ④ samples should have been relatively free of soil contamination
  - ④ soil has no nutritional value
- ④ Comprised mostly of the macrominerals calcium, potassium, phosphorus, sulfur, and magnesium, most of which contribute to the positive cation exchange capacity (CEC) of alfalfa
- ④ High CEC is linked to alfalfa's contribution to the diet's greater buffering capacity which promotes greater milk fat synthesis by the cow



FGI, 2022

# Fat

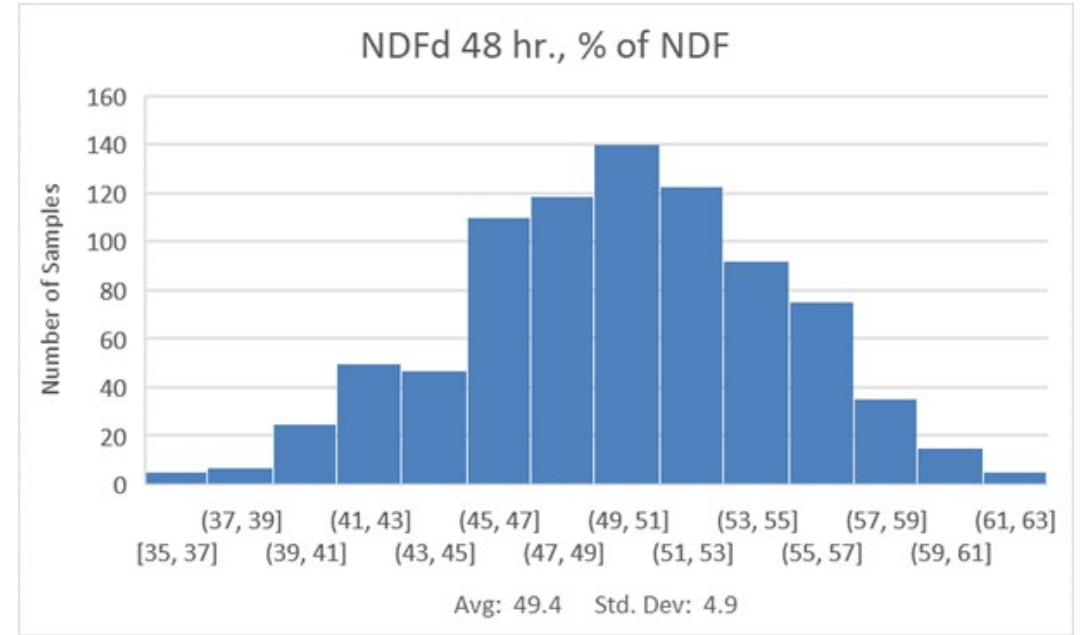
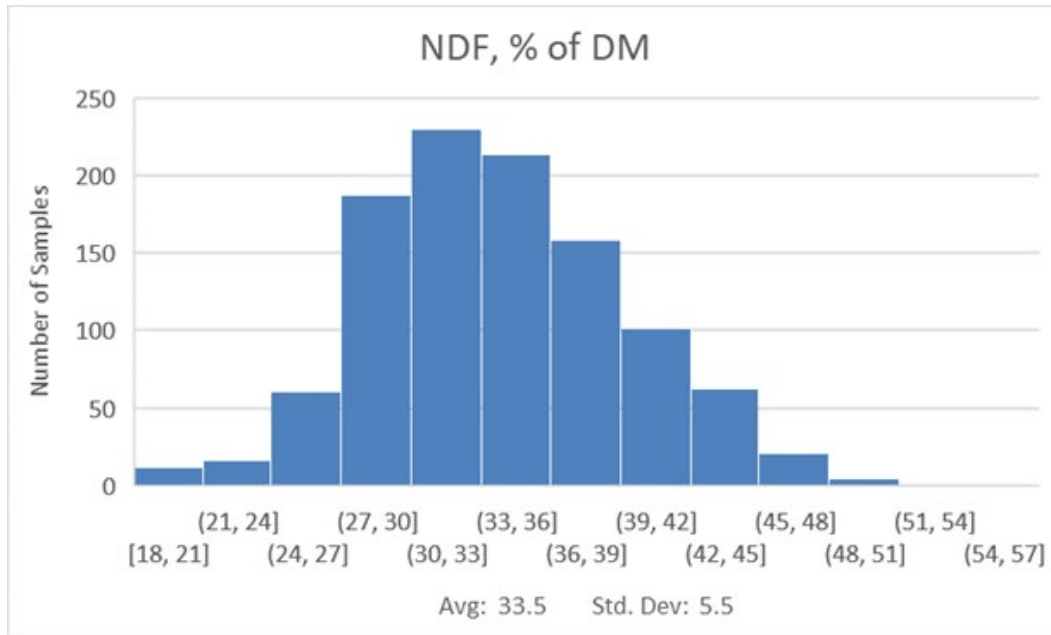
Ⓞ Average fat content, as measured after acid hydrolysis, was only 3.1%, with some samples as high as 5%.



FGI, 2022



# Fibrous Carbohydrates



FGI, 2022

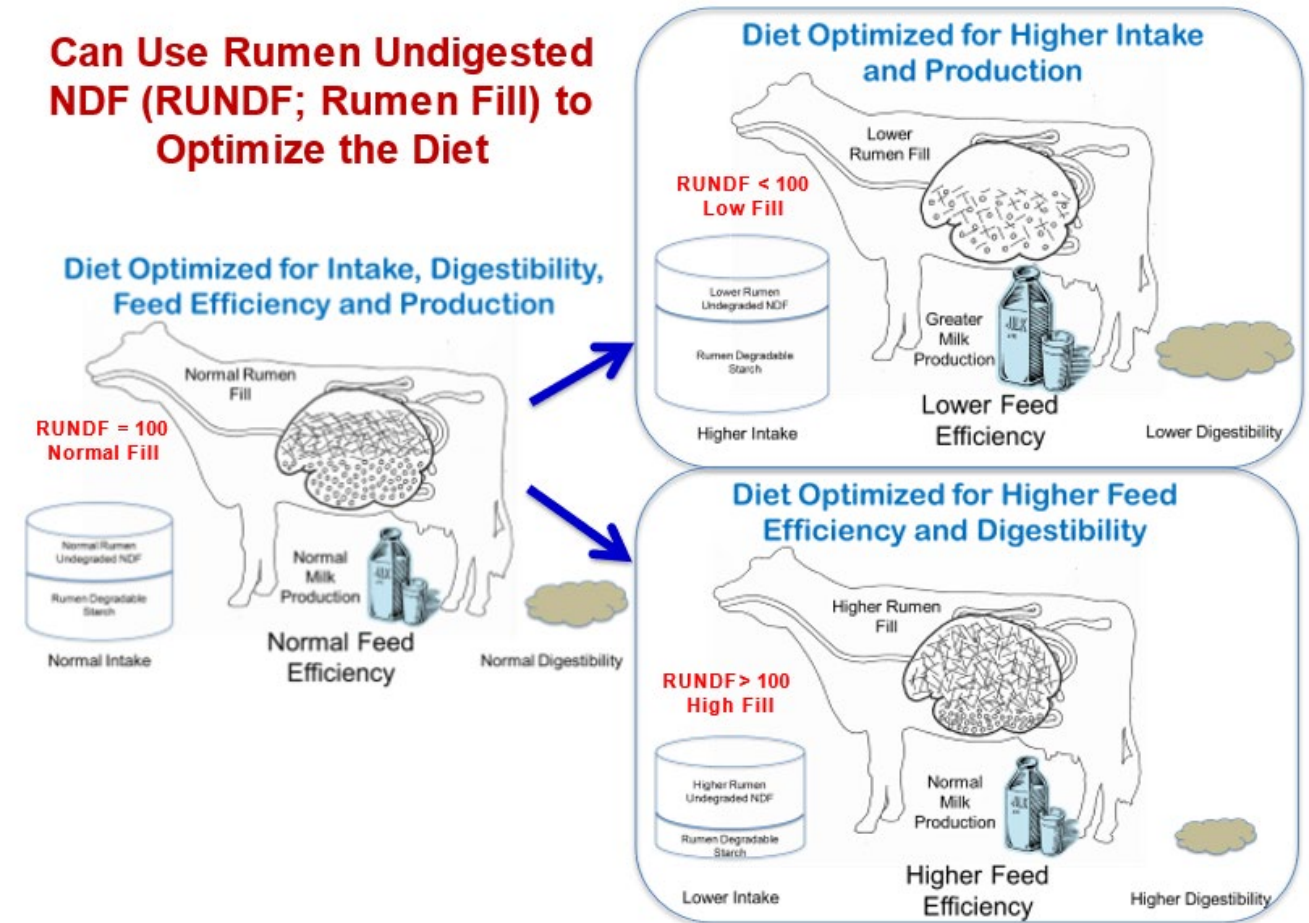
☉ Neutral detergent fiber (NDF) fraction represents the cell wall, or fibrous carbohydrate, portion of the plant comprising  $33.5\% \pm 5.5$  of the DM.

☉ Its digestibility (NDFd) averaged  $49.4\%$  of NDF  $\pm 4.9$ .

☉ The importance of both these measurements rests in their contribution to the Ruminant Undigested NDF (RuNDF) content of the diet.

# RuNDF is a proxy for rumen fill

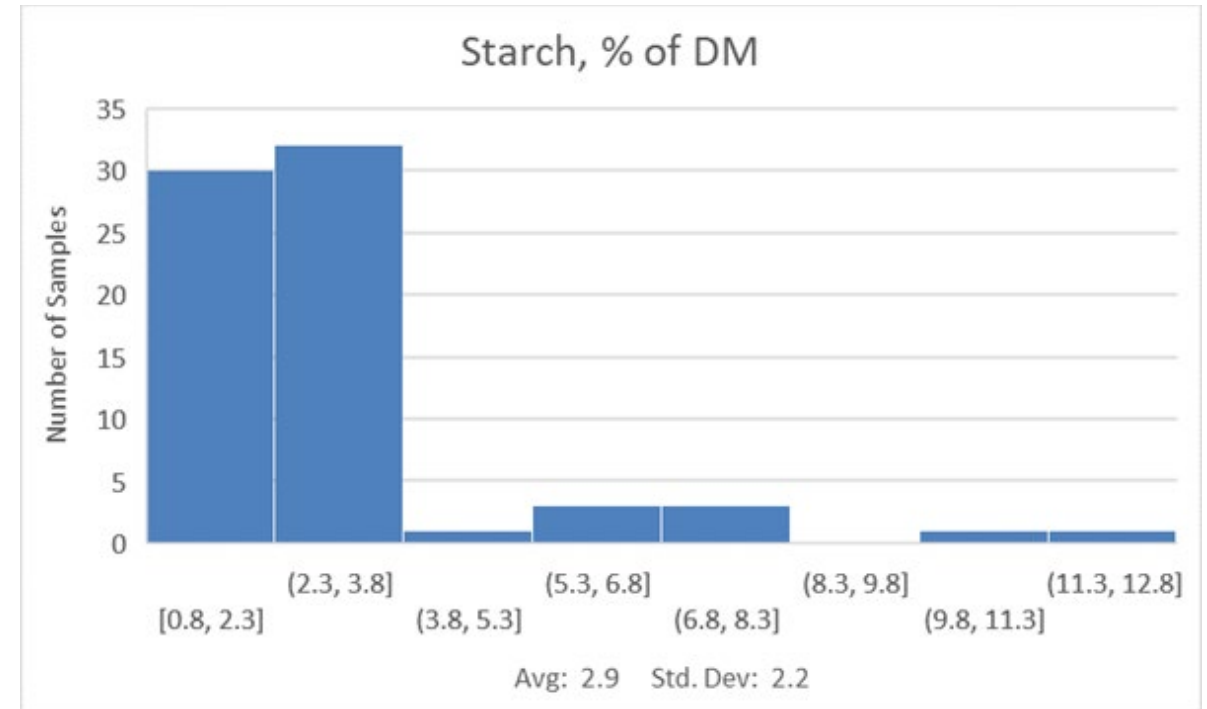
- ☉ Rumen fill is a critical factor in controlling animal performance.
- ☉ Most diets formulated at an optimum compromise in rumen fill where intake and milk production are maximized at an RuNDF level of approximately 11% of diet DM.
- ☉ Alfalfa is well suited in this respect since its RuNDF content is relatively moderate, compared to most other forages, because of its moderate NDF content, coupled with its high rate of NDFd.



Weakley, 2015

# Non-Fibrous Carbohydrates

- ④ For simplicity, composed of pectin, starch ( $2.9\% \pm 2.2$ ), and water-soluble carbohydrates (WSC).
- ④  $[\text{Pectin} + \text{WSC}] = 100 - [\text{CP} + \text{Fat} + (\text{Ash} - \text{NDF}_{\text{ash}}) + \text{NDF} + \text{starch}] = 28.2\%$ 
  - ④ Alfalfa has been reported to contain 10-14% pectin (Hatfield and Weimer, 1995; Jung et al., 2001).
  - ④ Remainder of the 28.2% is WSC.
  - ④ Pectin is rapidly degraded by rumen microbes producing acetate and propionate, but not lactate like rapidly fermented starch (Hatfield and Weimer, 1995).



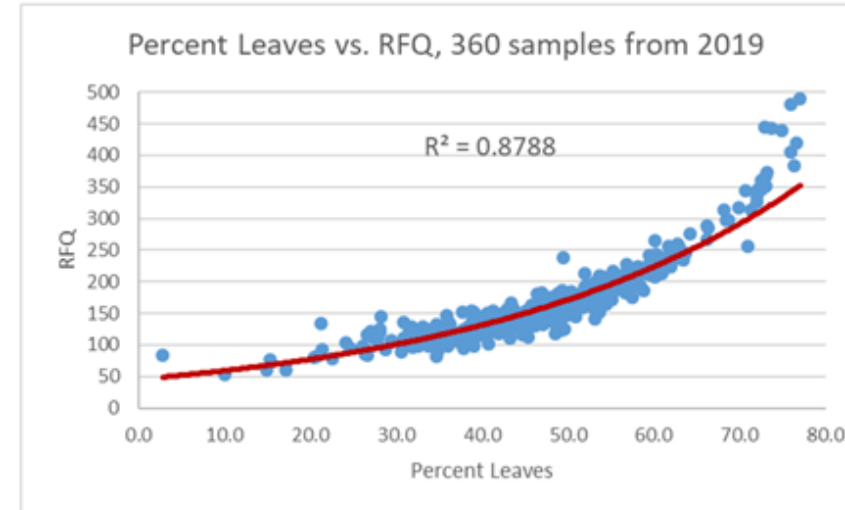
FGI, 2022

# The Importance of Leaves

## Nutritional Analysis of Leaves and Stems

	CP, %DM	Ash, % of DM	NDF, %DM	NDFd, %NDF	RFQ	RFV
<b>LEAVES</b>						
Average	29.1	11.2	19.7	60.3	442.3	367.3
Std. Dev.	2.2	0.7	1.4	4.0	36.3	29.5
<b>STEMS</b>						
Average	11.8	7.4	60.5	39.4	84.3	78.9
Std. Dev.	1.0	0.8	2.5	3.5	10.4	5.8

## Leaves influence RFQ in a curvilinear way



% leaves	RFQ
40	132
45	150
50	172
55	196
60	224

1 percentage unit leaves = 4.6 units of RFQ

- ☺ Leaves contain a higher concentration of protein and minerals, and less of NDF than stems.
- ☺ Relative Forage Quality (RFQ) value, a measure of alfalfa quality, confirms most of the nutritional value of alfalfa is contained in the leaves.
- ☺ A study with a different set of alfalfa samples showed that every 1% improvement in leaf retention garnered a 4.6 percentage unit improvement in RFQ.
- ☺ Retain leaves during the growing and harvesting phases to best capture the nutritional benefits of alfalfa, as well as improve harvested yield.

Weakley and Rodger, 2021



# Conclusions

- ④ NDF, NDFd, RUP, RDP, and ash are important nutrient components contributing to alfalfa's feeding value for ruminants.
- ④ The content of NDF, and its digestibility (NDFd), can have a major impact on intake, digestibility, and feed efficiency through their contribution to the RuNDF content of the diet.
- ④ The amount of RUP and RDP will contribute to the metabolizable protein content of the diet both directly and indirectly, through supporting ruminal microbial protein synthesis.
- ④ Knowing the proportions of RUP and RDP in the CP of alfalfa could help optimize the correct dietary balance to maximize the metabolizable protein supply to the ruminant at the greatest efficiency of CP use.

# Conclusions (cont'd)

- ④ An improvement to RFQ (or a new quality index) could be the addition of coefficients for the concentrations of RUP and RDP in alfalfa samples.
- ④ Preserving leaves in the alfalfa crop during growth, through to the point of feeding should help improve the quality of harvested alfalfa.
- ④ Additional study on the large fraction of pectin + WSC in alfalfa may identify benefits for ruminant feeding beyond that as an energy source in the rumen.