

# Forages: what do we know and what are we learning about feeding alfalfa to dairy cows?

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Four-State Dairy Nutrition & Management Conference  
December Webinar  
Friday December 19, 2025  
12 noon CST



# History of alfalfa as the “Queen of Forages”

- Oldest forage crop we have a name for
- Early French writers would call it “healthy hay”
- Excellent animal feed
- Improves soil
- Increases yield of other crops
- Used as human food and medication
- Despite the existence of fertilizer it continues to be important



“The alfalfa field near St. Denis,” by Georges Seurat (1800’s)

Russelle, 2001



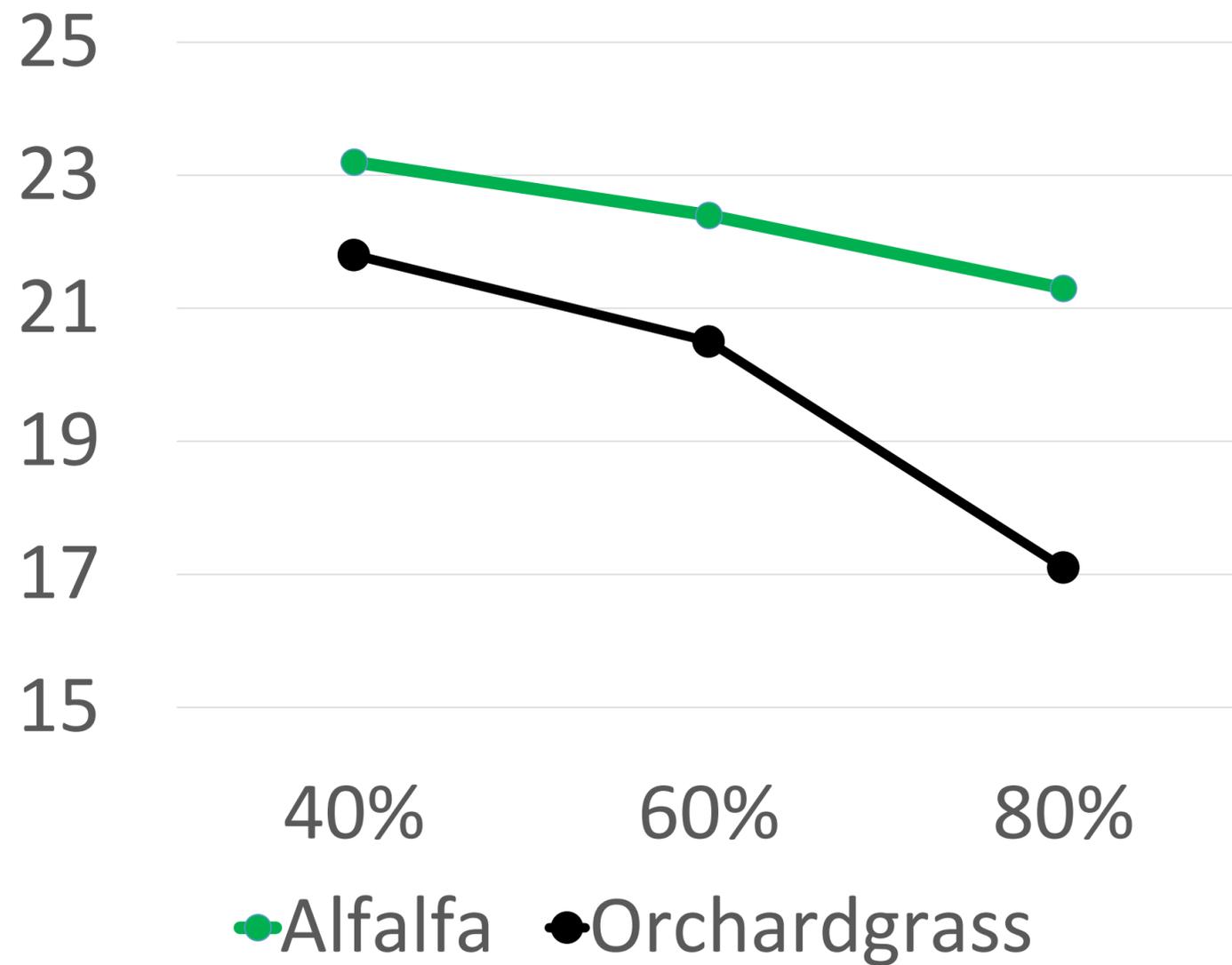
<b>Variables</b>	<b>NASEM High Cow<sup>1</sup></b>	<b>Alfalfa Hay<sup>1</sup></b>	<b>Orchardgrass<sup>1</sup></b>	<b>Corn Silage<sup>2</sup></b>
CP, % DM	17.4	20.7	11.4	7.7
RDP, % DM	10	16	4.7	5
ADF, % DM	.	32	36.4	24
NDF, % DM	25-33	41.1	58.2	40.9
Hemi, % DM		9.1	21.8	16.9
ADF/NDF	.	0.78	0.63	0.58
Lignin, % DM	.	6.64	6.30	3.05
Starch, % DM	22-30	1.5	1.37	32.9
NDFD48, % NDF	.	52.4	53.3 (30h)	52.0
DE, Mcal/kg		2.63	2.37	2.93
ME, Mcal/kg	2.73	2.21	1.94	2.51

<sup>1</sup>Kammes and Allen, 2012

<sup>2</sup>NASEM, 2021



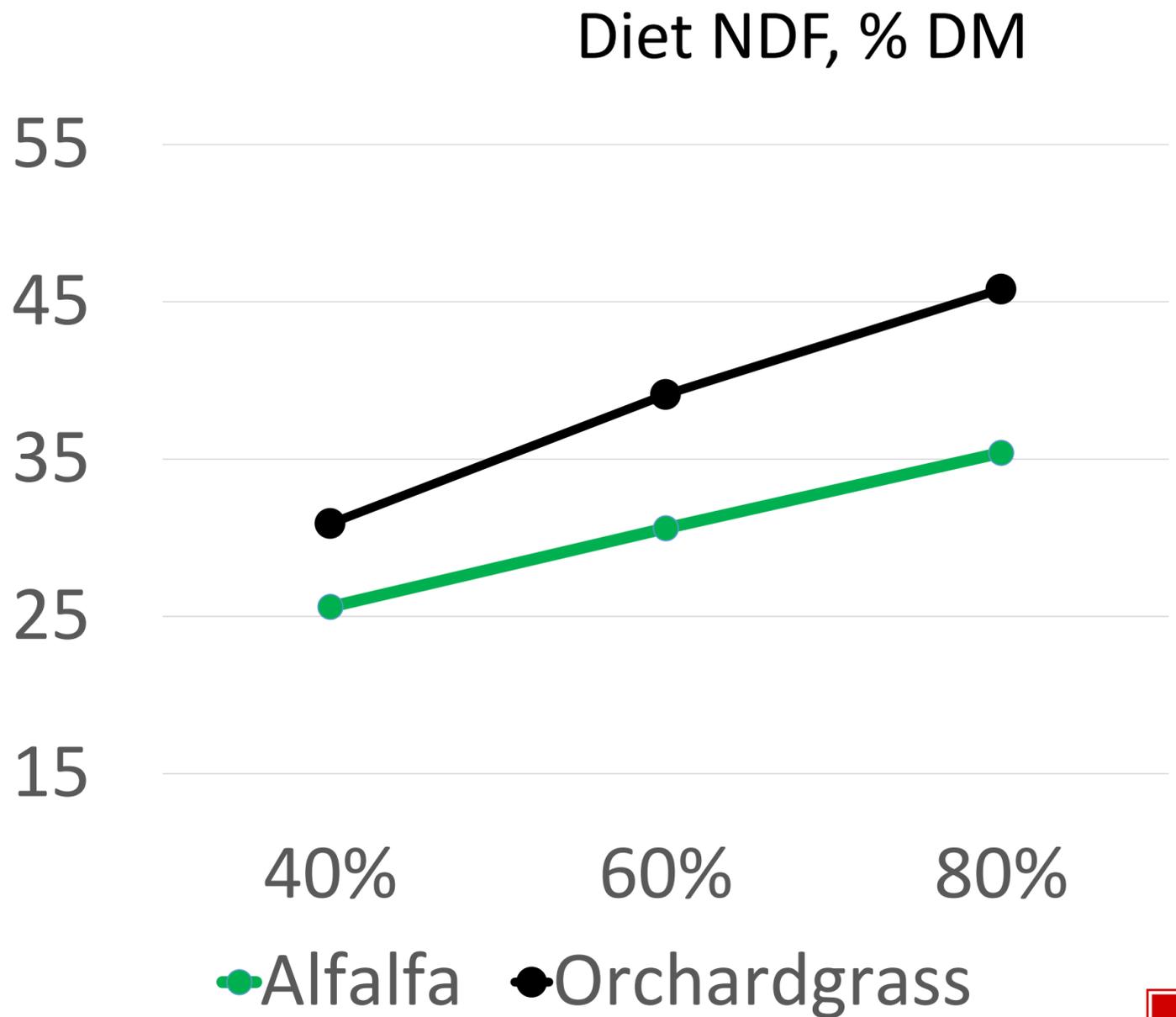
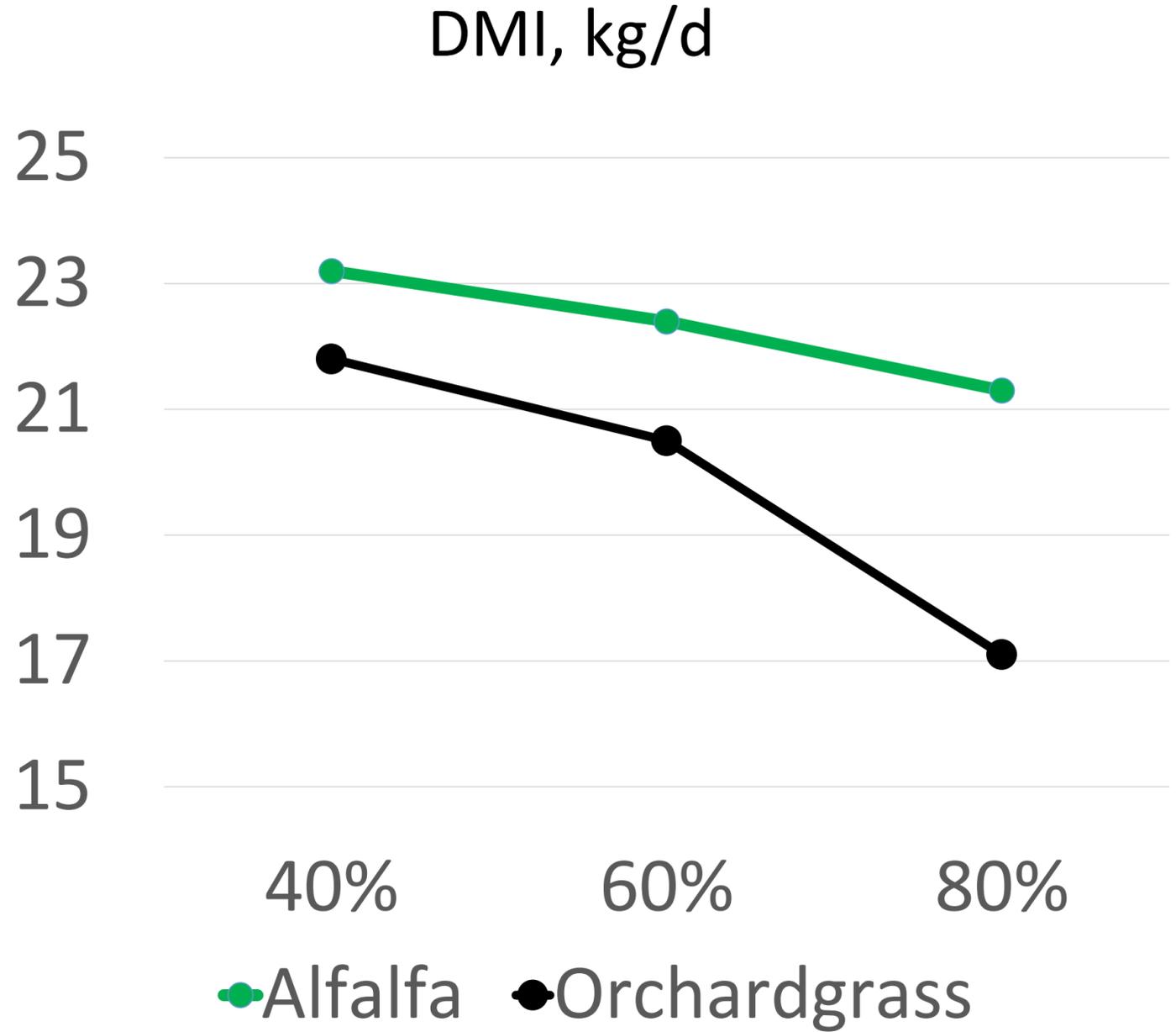
# Alfalfa and Orchardgrass Silage, DMI Kg/d



Weiss and Shockey, 1991



# Alfalfa (NDF = 40%) and Orchardgrass (NDF = 53%) Silage, DMI Kg/d

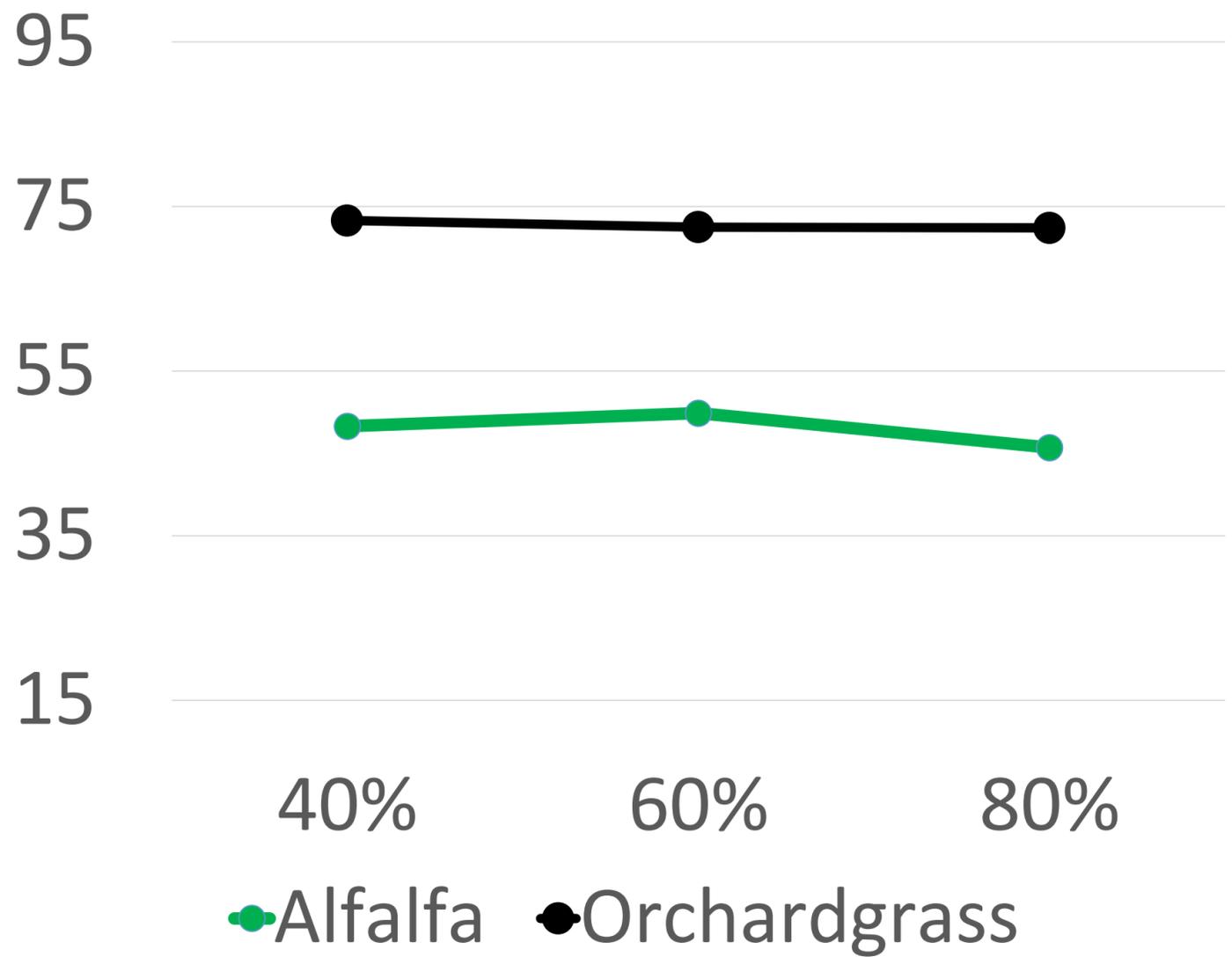


Weiss and Shockey, 1991

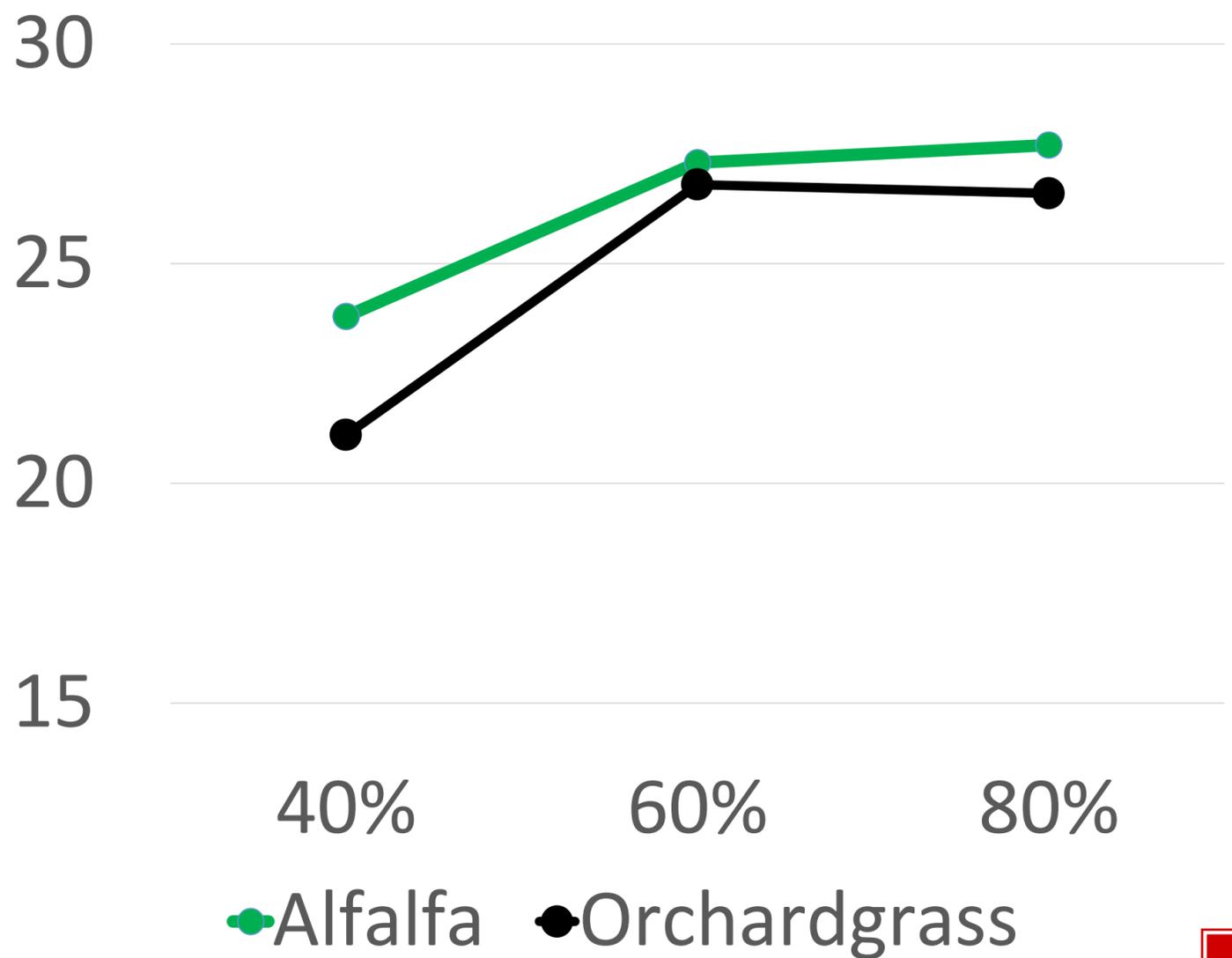


# Alfalfa (NDF = 40%) and Orchardgrass (NDF = 53%) Silage

NDF digestibility, %



Milk yield, Kg/d



Weiss and Shockey, 1991



## Kammes and Allen, 2012

- In general cows consuming grasses have lower DMI
- Many studies are confounded by concentration of NDF
- What happens if NDF is similar?



# Alfalfa vs Orchardgrass silage, forage composition

<b>Ingredient</b>	<b>Alfalfa silage</b>	<b>Orchardgrass silage</b>
CP, % DM	22.5	11.4
NDF, % DM	42.3	58.2
Lignin, % DM	7.56	6.03
NDFD30, % NDF	38.3	53.3

Kammes and Allen, 2012



# Alfalfa vs Orchardgrass silage, diet formulation

Ingredient	Alfalfa	Orchardgrass
Alfalfa Silage	59.9	-
Orchardgrass silage		42.7
Corn	33.6	36.6
SBM, 48%	-	11.8
Exp Soybean	2.50	3.39
Urea	-	1.2
Min/Vit	3.99	3.99
CP, % DM	18.4	17.0
NDF, % DM	29.2	30.2
Forage NDF, % DM	25.3	24.9
iNDF, % DM	14.8	8.24
Starch, % DM	27.3	29.6

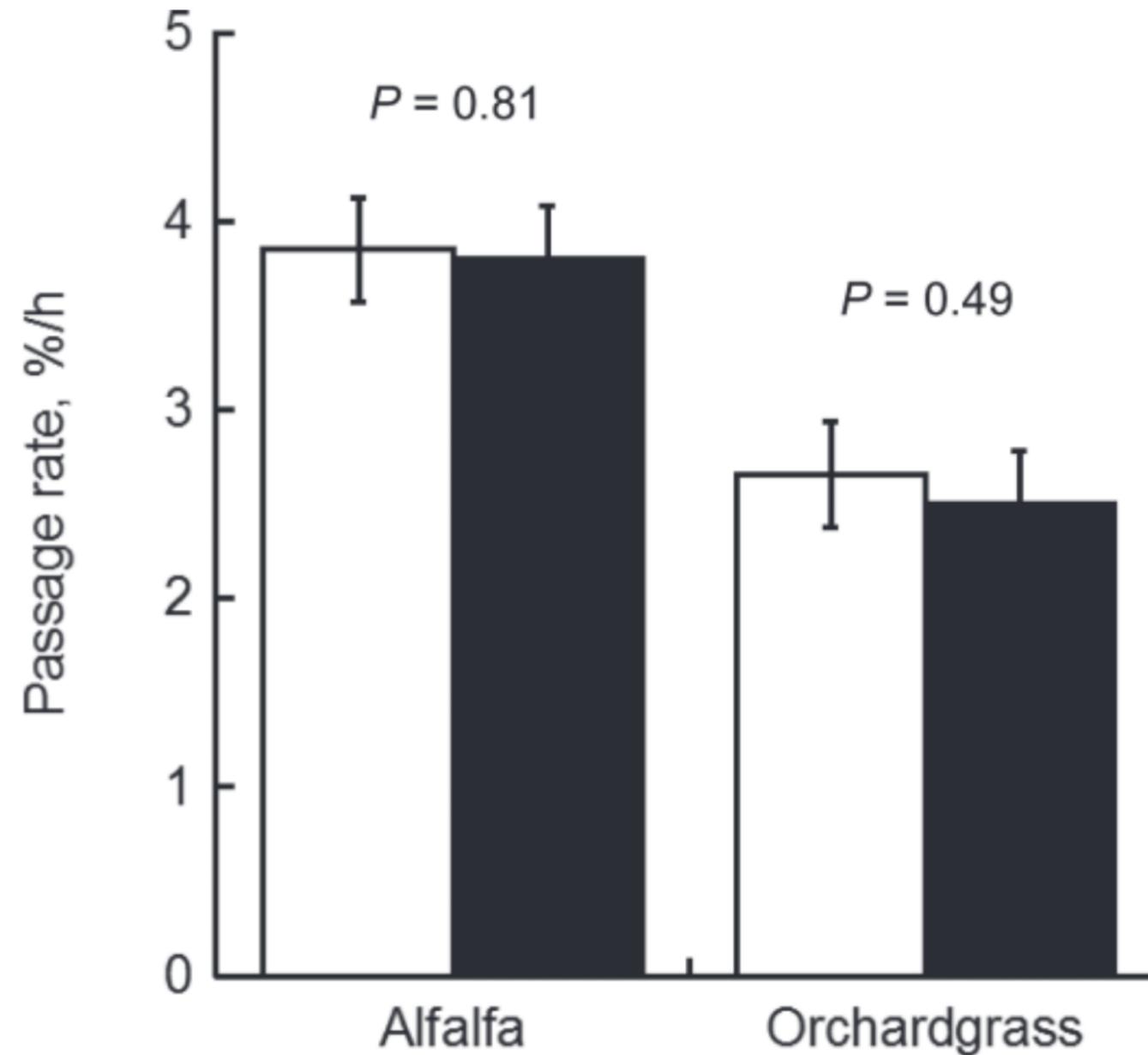
Kammes and Allen, 2012



# Alfalfa vs Orchardgrass silage

Ingredient	Alfalfa	Orchardgrass	SEM	P-value
DMI, kg	24.2	23.2	0.63	0.13
Milk yield, kg	35.1	35.2	2.3	0.92
3.5% FCM, kg	36.7	36.5	2.1	0.84
Fat, kg/d	1.33	1.31	0.07	0.72
Protein, kg/d	1.08	1.05	0.04	0.29
TTNDFD, %	72.0	64.7	2.1	0.02

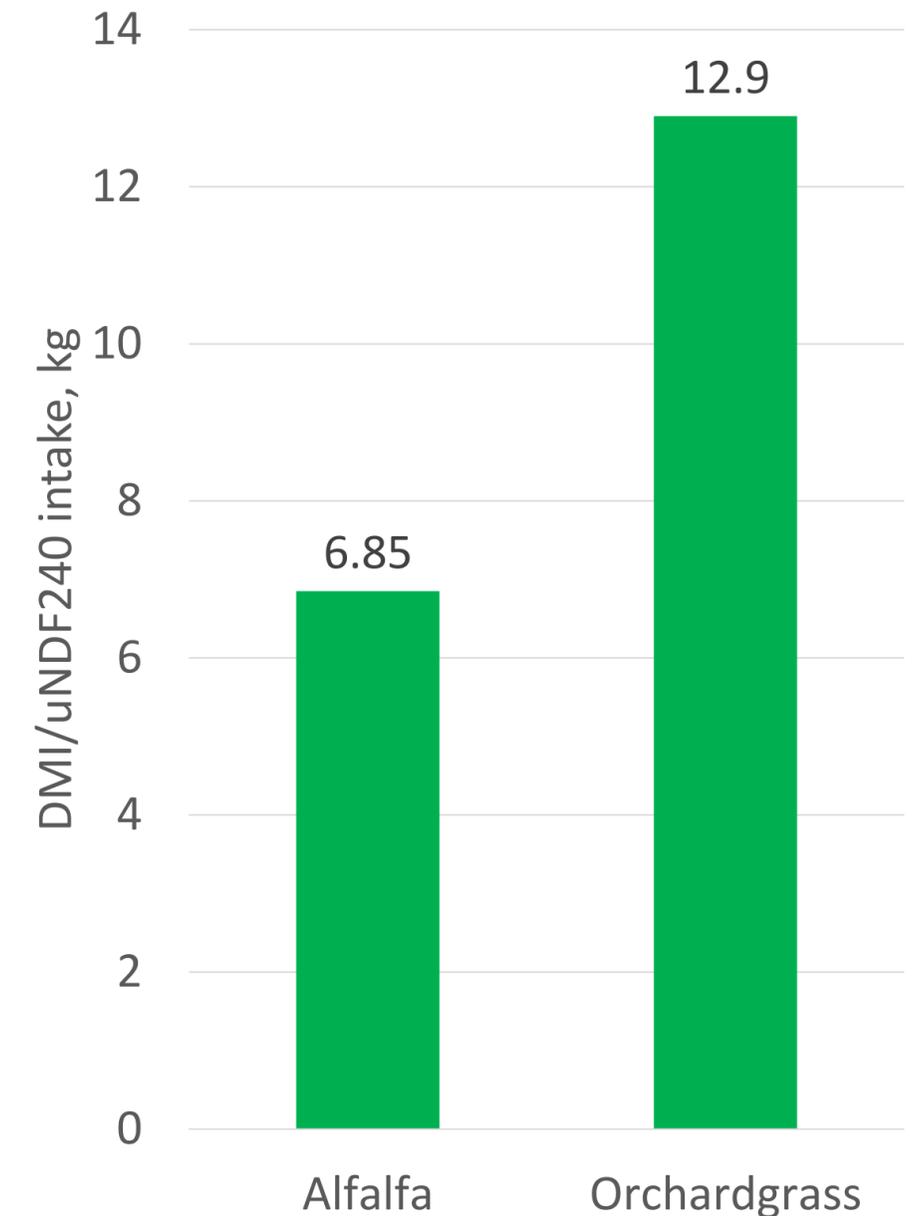




**Figure 4.** Passage rates of small (<2.36 mm) indigestible NDF particles (iNDF; white bars) and small potentially digestible NDF particles (pdNDF; black bars) for cows fed diets containing alfalfa or orchardgrass as the sole source of forage. Least squares means are shown and error bars represent standard error of the mean. *P*-values above each set of columns indicate significance for comparison of small iNDF and small pdNDF within alfalfa and orchardgrass based on analysis using a paired *t*-test.

## uNDF 240 h?

- Often used as a measure related to DMI (i.e.  $\uparrow$  uNDF240 =  $\uparrow$  DMI)
- Caution, the relationship may not hold across forage families
- Research by Kammes and Allen (2012)
- uNDF 240
  - Alfalfa = 23.0
  - Orchardgrass = 16.1



Allen (2018, 2021)

# Animal and Feed Factors [Eqtn 2.2, pg. 13]

$$\text{DMI (kg/d)} = 12.0 - 0.107 \times \text{fNDF} + 8.17 \times \text{ADF/NDF} + 0.0253 \times \text{fNDFD} - 0.328 \times (\text{ADF/NDF} - 0.602) \times (\text{fNDFD} - 48.3) + 0.225 \times \text{MY} + 0.00390 \times (\text{fNDFD} - 48.3) \times (\text{MY} - 33.1)$$

Diet filling effects are governed by

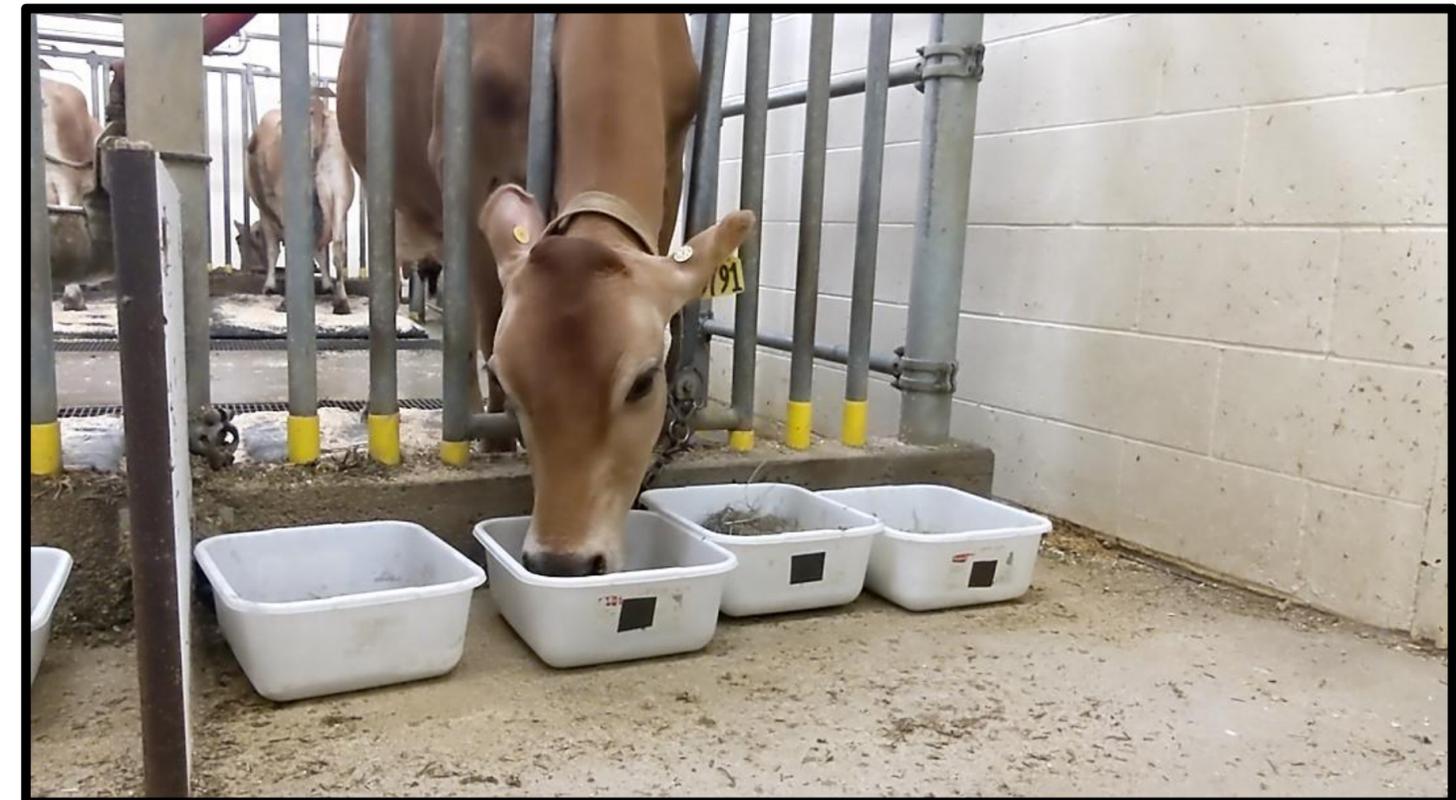
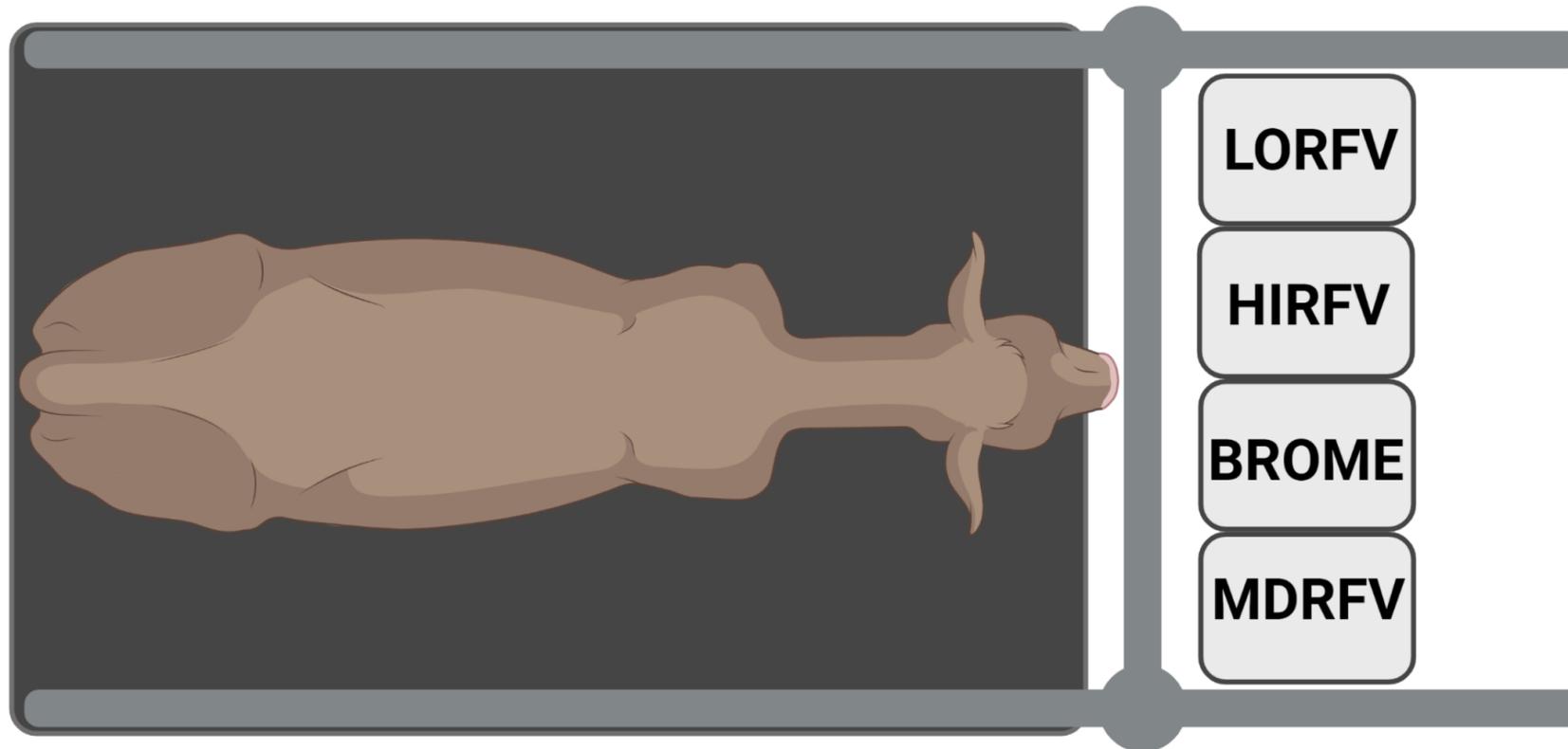
- Forage NDF content
- Fragility of forage NDF, ADF/NDF  
(Kammes and Allen, 2012)
  - Orchard grass ~ 0.63
  - Alfalfa ~ 0.82
  - Corn silage ~0.59
- NDF digestibility
- Not recommended for cows < 60 DIM



# Feed preference studies

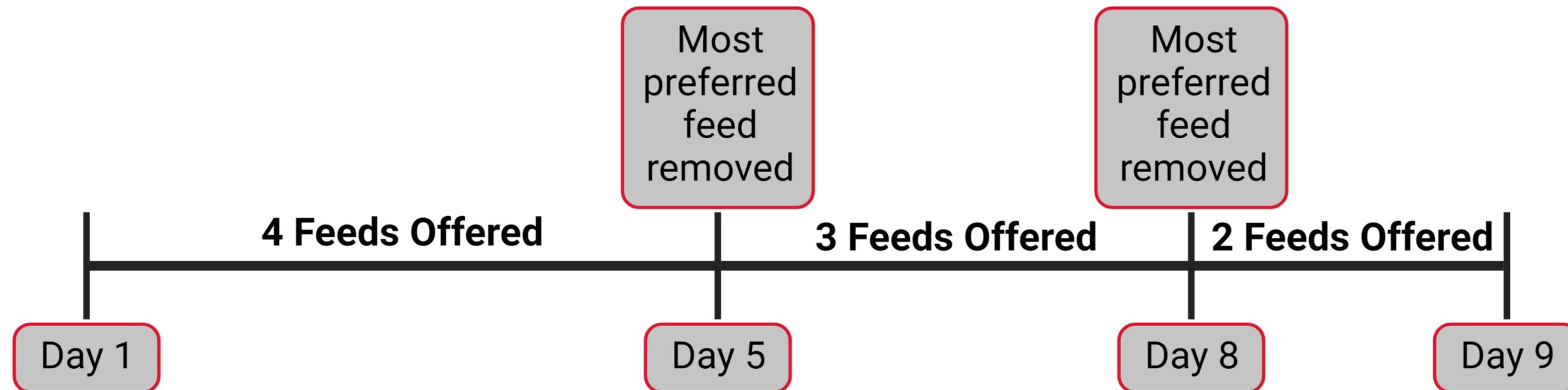
## Examining feed preference of different pellet formulations for application to automated milking systems

A. L. Carroll,<sup>1</sup> K. K. Buse,<sup>1</sup> J. D. Stypinski,<sup>1</sup> C. J. R. Jenkins,<sup>1,2</sup> and P. J. Kononoff<sup>1\*</sup>



# Feed preference, alfalfa and RFV

- High RFV alfalfa hay (**High RFV**; 213 RFV)
- Mid RFV alfalfa hay (**Med RFV**; 163 RFV)
- Low RFV alfalfa hay (**Low RFV**; 94 RFV)
- Brome grass hay (**Brome**; 75 RFV)
- Cows were offered 1.13 kg of each treatment in a random location within the feed bunk.



# Preference results between hays with differing RFVs

Item	Treatments <sup>1</sup>			
	High RFV	Med RFV	Low RFV	Brome
Sum	17	44	41	52
Mean rank (SD)	1.06 (0.25)	2.75 (0.58)	2.56 (0.63)	3.25 (0.93)
Prob. 1 <sup>st</sup> Choice (SEM) <sup>1</sup>	97.7 (0.79)	1.70 (0.38)	2.09 (0.38)	0.55 (0.46)

<sup>1</sup> P < 0.05

# Feed preference and alfalfa pellets

Carroll et al., 2023

Ingredients	Treatments			
	ALFC	ENG	DALF	GMIX
Alfalfa meal	45.7		100	
Corn, rolled	45.7	72.3		43.1
Dried corn distillers grains and solubles		9.25		26.3
Wheat middlings	8.57	18.5		13.8
Soybean meal				3.18
Dry molasses				7.10
Corn oil				0.93
Remaining mix <sup>2</sup>				5.60
Chemical Composition				
DM, % as-is	86.1	88.1	92.3	88.1
CP, % DM	13.3	12.9	17.9	16.1
aNDFom, % DM	23.1	21.0	44.4	20.1
Starch, % DM	37.8	50.3	1.6	35.9
Fatty Acids, % DM	2.15	4.99	1.24	4.22
Hardness, kg of force (SD)	20.6 (5.68)	19.8 (4.24)	41.2 (4.81)	11.9 (5.47)



# Pelleting alfalfa and feed preference

	Treatment			
	ALFC	ENG	DALF	GMIX
Mean rank (SD)	1.38 (0.518)	2.13(1.126)	3.13 (0.835)	2.88 (0.835)
Probability of 1 <sup>st</sup> choice (SEM) <sup>1</sup>	76.61 (0.55)	16.5 (0.46)	7.48 (0.455)	5.50 (0.475)

<sup>1</sup> P < 0.05



# Alfalfa and DDGS?

Items	Treatments <sup>1</sup>			
	Corn Silage		Alfalfa Haylage	
	DDGS (55% CP)	Exp Soy	DDGS (55% CP)	Exp Soy
<b>Ingredients</b>				
Corn silage	39.4	39.4	18.0	18.0
Alfalfa haylage	18.0	18.0	39.4	39.4
Corn grain, ground	16.1	16.1	25.0	25.0
Expellers soy	0	10.0	0	7.78
High protein coproduct <sup>2</sup>	10.0	0	7.78	0
Soybean meal	3.33	3.33	0.83	0.83
Blood meal	0.78	0.78	0.67	0.67
Urea	0.49	0.40	0	0
Rumen protected MET <sup>3</sup>	0.02	0.05	0.06	0.08
Soybean hulls, ground	2.58	3.31	0.91	1.34
Molasses, beet	2.10	2.10	1.83	1.81
Fat <sup>4</sup>	3.11	3.11	3.11	3.11
Min/Vit	4.10	4.10	4.10	4.10

Buse et al., 2022



# Production

Item	Treatments				SEM	P-value <sup>3</sup>		
	Corn Silage		Alfalfa Haylage			F	P	F×P
	DDGS	Exp Soy	DDGS	Exp Soy				
DMI, kg/d	19.6	19.7	19.9	19.6	0.44	0.79	0.77	0.46
Milk yield, kg/d	28.5	29.1	27.9	28.2	0.61	0.09	0.29	0.72
ECM, kg/d <sup>3</sup>	36.4	36.1	36.7	36.1	0.60	0.77	0.29	0.60
Protein, %	3.56	3.46	3.45	3.45	0.06	0.07	0.11	0.11
Protein, kg/d	1.01	1.00	0.96	0.97	0.03	0.01	0.99	0.52



# Alfalfa silage and MP Supply

<b>Ingredient</b>	<b>- MP + ME</b>	<b>+ MP + ME</b>
Alfalfa silage	51.0	51.0
Corn Silage	17.0	17.0
Ground corn	12.6	20.3
Corn starch	13.6	0.0
SBM	0.0	7.6
Blood meal	2.4	1.1
Min/Vit/other	3.4	3.0



## Alfalfa silage versus corn silage, diet composition (% DM)

Ingredient	- MP + ME	+ MP + ME	SEM	P-Value
DMI, kg	24.5	26.0	0.93	0.04
Milk yield, kg	30.2	33.6	1.84	< 0.01
ECM, kg	30.5	33.8	2.09	< 0.01
Composition				
Fat, kg/d	1.27	1.40	0.100	< 0.01
Protein, kg/d	1.00	1.11	0.059	< 0.01
MUN, mg/dL	10.5	16.2	0.56	< 0.01
Estimate AA Eff'n				
Met	0.60	0.61		
Lys	0.62	0.63		
Ile	0.75	0.66		

Laroche et al., 2019



# Feeds and AA composition

Nutrient	Unit	Alfalfa	Soybean meal, solvent	Bloodmeal
Arg	% CP	4.20	7.29	4.20
His	% CP	1.93	2.64	6.00
Ile	% CP	3.92	4.54	1.08
Leu	% CP	6.69	7.63	12.40
Lys	% CP	4.81	6.16	8.77
Met	% CP	1.33	1.38	1.15
Phe	% CP	4.59	5.03	6.79
Thr	% CP	4.03	3.95	4.55
Trp	% CP	1.38	1.38	1.58
Val	% CP	4.97	4.76	8.32



# Lignin and alfalfa

## Alfalfa biotypes with putative enhanced cell wall digestibility and effects on performance of growing beef steers

Caleb W. Karls,<sup>†</sup> David K. Combs,<sup>†</sup> M. Liou,<sup>‡</sup> and Daniel M. Schaefer<sup>†,1</sup> 

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<sup>1</sup>Corresponding author: [dmschae@wisc.edu](mailto:dmschae@wisc.edu)

Item	Control	Hi-Gest	HarvXtra	SEM	P-value
CP	178 <sup>b</sup>	194 <sup>a</sup>	189 <sup>a</sup>	2.0	<0.01
NDF	446	455	445	13.1	0.79
ADF	383	386	376	10.1	0.58
ADL	75.6	71.8	63.0	7.6	0.34
RFV	123	121	124	3.7	0.70
TDN	556	563	579	13.7	0.34
Net energy, Mcal/kg DM					
NE <sub>m</sub>	1.17	1.21	1.28	0.07	0.34
NE <sub>g</sub>	0.616	0.638	0.704	0.04	0.34

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	Control	Hi-Gest	HarvXtra	SEM	P-value
NDF, g/kg DM	437	439	446	5.7	0.35
NDF digested, g/kg NDF					
24 h	176	207	195	9.1	0.06
30 h	219	249	264	15.3	0.09
48 h	352	373	415	21.4	0.09
iNDF <sup>1</sup> , g/kg NDF	568 <sup>a</sup>	489 <sup>b</sup>	467 <sup>b</sup>	13.4	<0.01
k <sub>d</sub> of pdNDF <sup>2</sup> , h <sup>-1</sup>	0.050 <sup>a</sup>	0.034 <sup>b</sup>	0.044 <sup>a</sup>	0.0034	0.02
TTNDFD coefficient <sup>3</sup>	0.315	0.316	0.370	0.021	0.10

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	<b>Control</b>	<b>Hi-Gest</b>	<b>HarvXtra</b>	<b>SEM</b>	<b>P-value<sup>2</sup></b>
DMI, kg/d	6.49 <sup>b</sup>	6.87 <sup>a</sup>	6.66 <sup>ab</sup>	0.22	0.02
Initial BW, kg/steer	300	300	300	0.87	0.64
Final BW, kg/steer	378	383	389	6.51	0.28
ADG <sup>3</sup> , kg/(steer × d)	0.94	1.00	1.07	0.07	0.25
Alfalfa DMI <sup>4</sup> , kg/(steer × d)	7.23	7.65	7.77	0.47	0.51
Gain efficiency <sup>5</sup>	0.129	0.132	0.139	0.014	0.78
NDF intake, kg/(steer × d)	3.22	3.48	3.46	0.21	0.44

# Lignin and alfalfa

	Corn silage			Control <sup>2</sup>			Test <sup>3</sup>	
Item	Mean	SD		Mean	SD		Mean	SD
DM, % as-is	33.6	3.65		89.0	1.42		88.6	2.52
CP	8.33	0.86		20.5	1.15		19.8	0.75
SP	4.03	1.20		7.27	0.49		6.43	0.64
NDF	32.7	2.8		42.1	1.37		39.9	1.56
NDFom	32.2	3.35		40.9	1.51		38.8	1.47
ADF	20.1	1.30		33.9	2.65		32.2	1.07
Lignin	2.94	0.48		6.81	0.57		6.07	0.28
RFV <sup>4</sup>	<sup>-5</sup>	-		142	8.72		151	7.00

# Lignin and alfalfa, Diets

Items, % DM	Treatment <sup>1</sup>		
	Control	Mix Low	Mix High
Corn silage	18.2	18.2	18.2
CON alfalfa hay <sup>2</sup>	32.2	16.1	0
Test alfalfa hay mix	0	16.1	32.2
Corn grain, ground	25.5	25.5	25.5
Concentrate	24.1	24.1	24.1

# Lignin and alfalfa, Total tract digestibility

Item	Treatment <sup>1</sup>			SEM	P-value	
	Control	Low Mix	High Mix		L	Q
DM	67.3	67.2	67.0	0.94	0.62	0.95
OM	68.0	67.9	67.9	0.93	0.98	0.99
NDF	52.6	50.1	50.1	2.20	0.27	0.51
NDF <sub>OM</sub>	53.6	51.8	52.3	2.48	0.57	0.57
CP	67.1	66.8	66.1	0.95	0.20	0.81
Starch	85.9	87.9	88.3	2.22	0.23	0.62
Energy	65.9	65.6	66.2	0.87	0.71	0.50

# Lignin and alfalfa, Production

	Treatment			SEM	P-Value	
	Control	Low Mix	High Mix		L	Q
DMI, kg/d	20.7	20.3	20.1	0.37	0.20	0.80
Milk yield, kg/d	30.7	31.5	30.8	0.48	0.75	0.11
ECM, kg/d	36.0	36.3	36.3	0.76	0.68	0.83
ECM/ DMI	1.74	1.79	1.8	0.03	0.10	0.59
Fat, %	4.55	4.4	4.59	0.15	0.83	0.27
Fat, kg/d	1.38	1.37	1.41	0.05	0.69	0.63
Protein, %	3.45	3.43	3.41	0.05	0.48	0.99
Protein, kg/d	1.05	1.08	1.05	0.02	0.89	0.27

Buse, K., B. Bradford, M. Doohong, K. Jagadish, and P. Kononoff. 2024. The effect of displacing conventional alfalfa with lower-lignin alfalfa hay on milk production and gas production of lactating Jersey cows. J. Dairy Sci. Vol.

# Summary

- Alfalfa has many agronomic advantages
- Protein is highly soluble in the rumen
- Compared to corn silage alfalfa supplies less energy
  - DMI usually lower
- Compared to some forages like (i.e. orchardgrass) fiber is more “fragile”
  - DMI usually higher
- Things not considered by some nutrition models
  - Fragility (ADF/NDF)
  - Palatability



