Identifying Opportunities for Maximizing Forage Utilization

Forage intake, digestion and milk production by dairy cows

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Response to alfalfa silage:grain ratio[1,2]

Tessman et al., 1991, JDS

Item	38,48,68 53% AS	48,58,78 64% AS	58,68,88 73% AS	68,88,98 87% AS	98% AS
DMI, kg/d	21.6[ab]	22.5[a]	21.1[ab]	20.6[b]	19.0[c]
305d FCM, kg	8295[ab]	8659[a]	7563[bc]	6849[cd]	6000[d]
305d Cheese Yield, kg	826[a]	852[a]	735[b]	663[b]	575[c]
Final BCS	3.7	3.5	3.5	2.9	2.9

[1]44 multiparous cows over 44 wk lactation study

[2]AS NDF = 44 ± 5; AS ADL = 6.8 ± 1

Response to alfalfa:corn silage ratio[1,2]

Dhiman and Satter, 1997, JDS

Item	50% AS	33% AS 17% CS	17% AS 33% CS
DMI, % of BW	3.51[b]	3.75[a]	3.57[b]
Milk, kg/d	31.1	32.4	31.4
Milk Fat, %	3.53	3.67	3.65
Milk Protein, %	3.08[b]	3.15[a]	3.19[a]
Protein Efficiency, %[3]	29.5	31.5	33.5

[1]45 multi- & 29 primi-parous cows over 36 wk lactation study

[2]AS NDF = 40 ± 5; CS NDF = 45 ± 5

[3]$P < 0.10$

Response to alfalfa silage IVNDFD[1]

Dado and Allen, 1996, JDS

Item	LNDFD	HNDFD
AS NDF, %	40 (41)	40 (39)
AS 24-h IVNDFD, % of NDF	40 (38)	45 (41)
DMI, kg/d	19.4[b]	20.4[a]
Milk, kg/d	36.3[b]	38.2[a]

[1]Early lactation cows fed 83% AS diets

Response to alfalfa hay NDF & ISNDFD[1]

Llamas-Lamas and Combs, 1990, JDS

Item	Early Veg.	Full Bloom
Hay NDF, %	36	52
Hay ISNDFD, % of NDF	65	42
Diet, % Hay	68	45
% NDF	32 (33)	31 (28)
% NDF from hay	24	23
DMI, kg/d	26.1[a]	24.8[b]
FCM, kg/d[1]	30.6	29.2

[1]P < 0.10

Response to alfalfa hay NDF & IVNDFD

Mertens et al. & Raeth-Knight et al., 2005, JDS abstr.

	LNDF LNDFD	LNDF HNDFD	HNDF LNDFD	HNDF HNDFD
Hay NDF	36%	37%	41%	42%
Hay IVNDFD	38%	41%	41%	45%
Milk kg/d, WI	45.0	43.8	45.4	46.9
ECM kg/d, MN	35.4	34.2	36.3	36.3

- **WI Trial - Hays at 30% of diet DM**
- **MN Trial - Hays at 15% of diet DM**

Response to bm_3 corn silage IVNDFD[1]

Oba and Allen, 1999, JDS

Item	Isogenic	bm_3
CS NDF, %	40 (40)	42 (38)
CS 30-h IVNDFD, % of NDF	37 (39)	45 (49)
DMI, kg/d[2]	23.5[b]	25.7[a]
FCM, kg/d[2]	38.4[b]	41.0[a]
Apparent TT OMD, %	62.6	63.2

[1]32 multiparous early/mid lactation cows fed 56% forage diets

[2]Cows with > pre-trial milk yield had > increases ($P<0.03 – 0.06$)

Response to bm_3 corn silage IVNDFD[1,2]

Oba and Allen, 2000, JDS

	Isogenic	bm_3	Isogenic	bm_3
Diet NDF	29%	29%	38%	38%
DMI, kg/d	23.9[b]	24.7[a]	21.5[y]	22.9[x]
Milk, kg/d	33.5[b]	36.9[a]	30.4[y]	33.7[x]
Milk Fat, %	3.67[a]	3.28[b]	3.90	3.86
SCM, kg/d	31.6[b]	32.9[a]	29.5[y]	32.7[x]
aTT OMD, %	69.5	68.6	70.3	67.9

[1]CS 30-h IVNDFD 47% for isogenic vs. 56% for bm_3

[2]42% vs. 65% forage in low & high NDF diets

Response to bm_3 corn silage[1]

Bal et al., 2000, JDS

Item	Conventional	bm_3
Diet Forage, %	48	61
Diet NDF from forage, %	19	23
DMI, kg/d	28.4	28.4
FCM, kg/d	38.6	39.1
Milk Fat, %	3.2[b]	3.5[a]

[1]26 multi-parous mid lactation cows

Response to corn silage NDF & IVNDFD[1,2]

Ivan et al., 2005

Item	LCW	HCW
CS NDF, %	49	53
CS 48-h IVNDFD	58	67
Diet, % CS	45	45
% NDF	31	33
% NDF from CS	22	24
DMI, kg/d	24.2[b]	25.4[a]
FCM, kg/d[2]	31.7[b]	34.3[a]
aTT OMD, %	62.1	61.2

[1]40 mid lactation cows fed 55% forage diets

[2]Cows with > pre-trial milk yield had > increases ($P<0.08$)

Energy content of bm_3 corn silage[1,2]

Tine et al., 2001, JDS

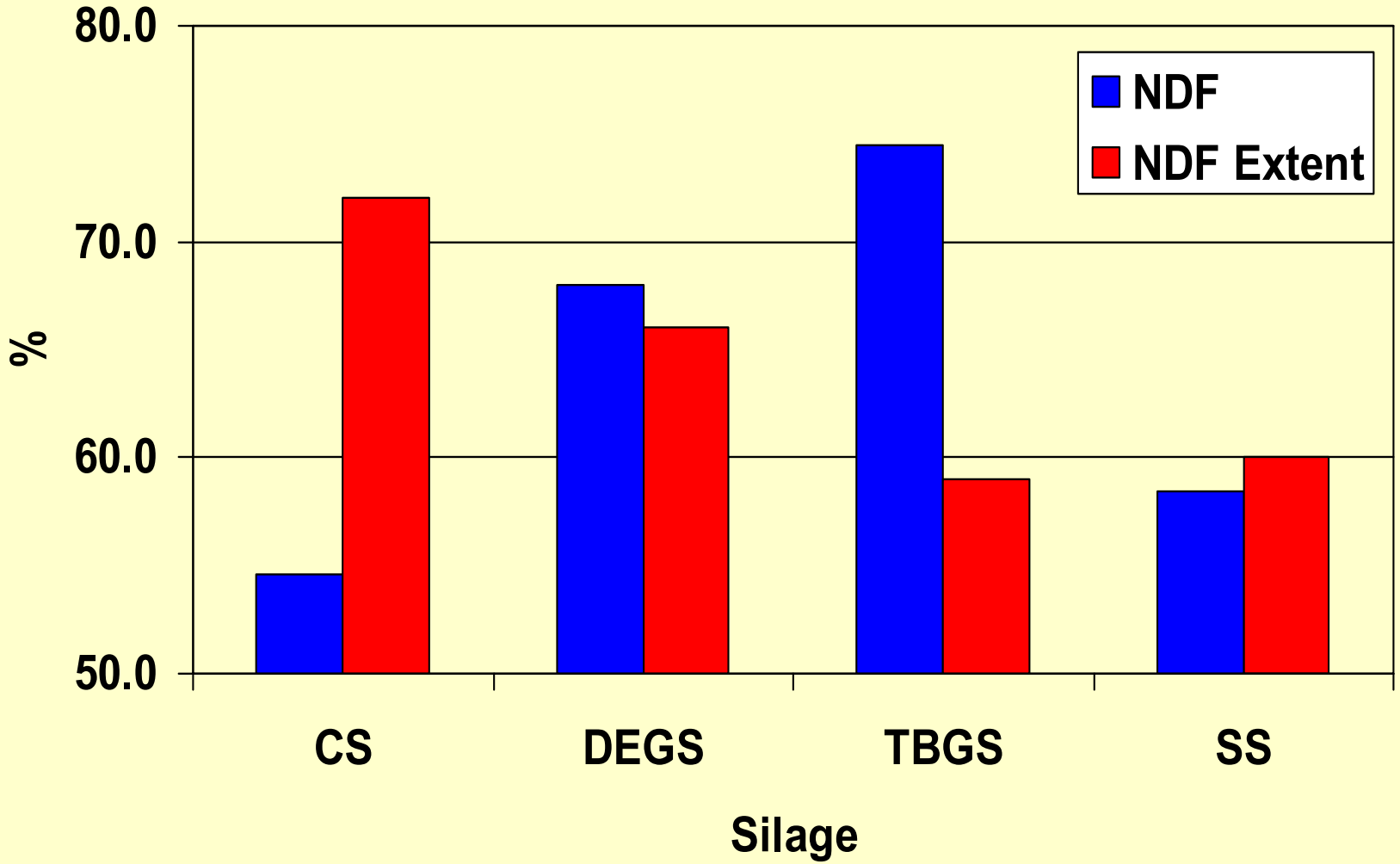
Item	Lactating 4x Maintenance		Dry Maintenance	
	Isogenic	bm_3	Isogenic	bm_3
TDN, %	---	---	72.1[b]	74.8[a]
DE, Mcal/kg	3.10	3.12	3.20[b]	3.32[a]
ME, Mcal/kg	2.58	2.68	2.62[b]	2.77[a]
NE_L, Mcal/kg	1.43	1.49	1.42	1.54

[1]CS dry cow aTTNDFD 62% for isogenic vs. 72% for bm_3

[2]60% CS in lactating & 98% CS in dry cow diets

NDF & ISNDFextent of diverse forages

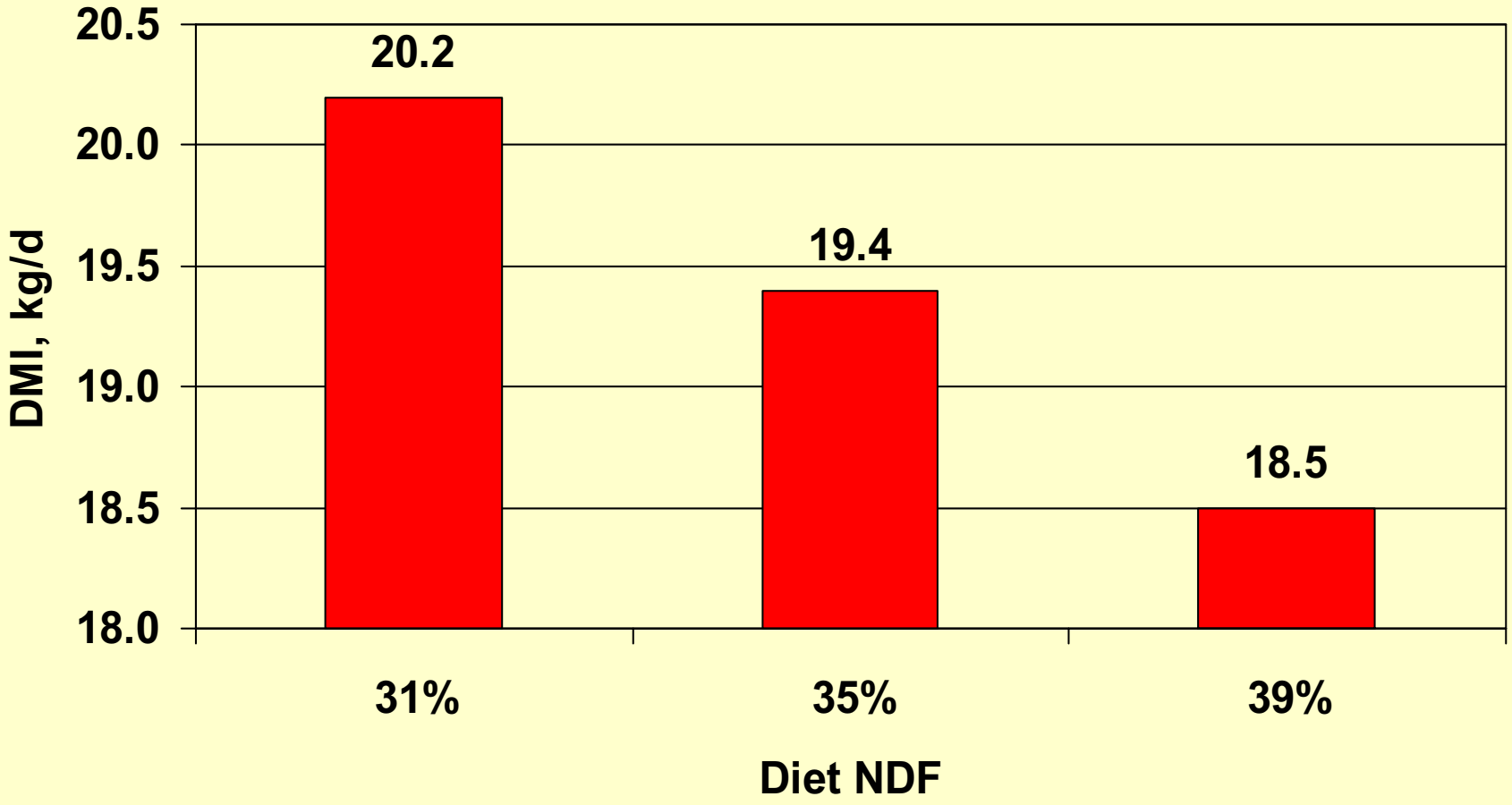
Ruiz et al., 1995



Fed in 31, 35, & 39% NDF diets to 48 mid lactation cows

Response to diet NDF using diverse forages

Ruiz et al., 1995

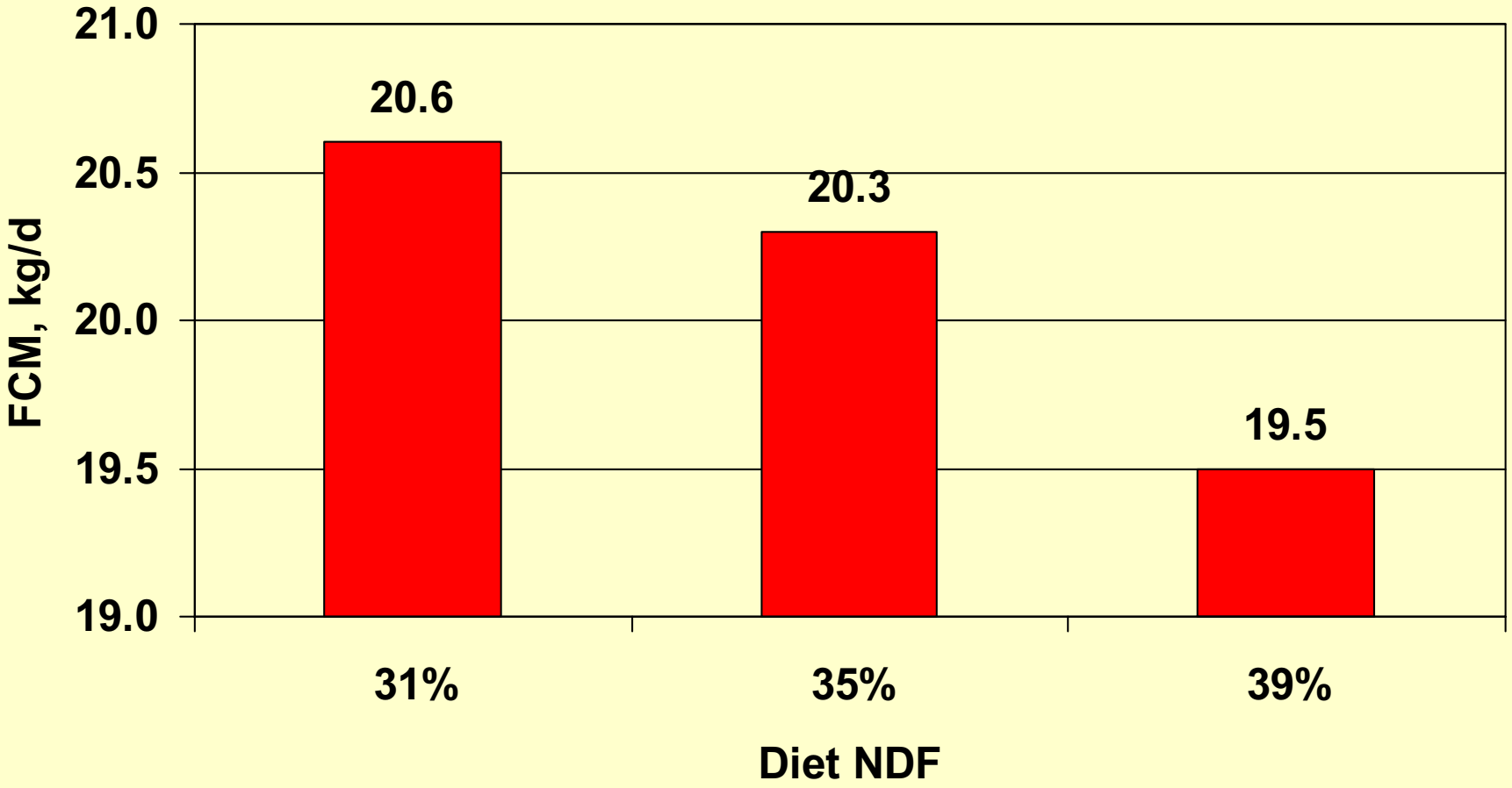


DMI averaged across CS, DEGS, TBGS, SS

Linear effect ($P < 0.01$)

Response to diet NDF using diverse forages

Ruiz et al., 1995

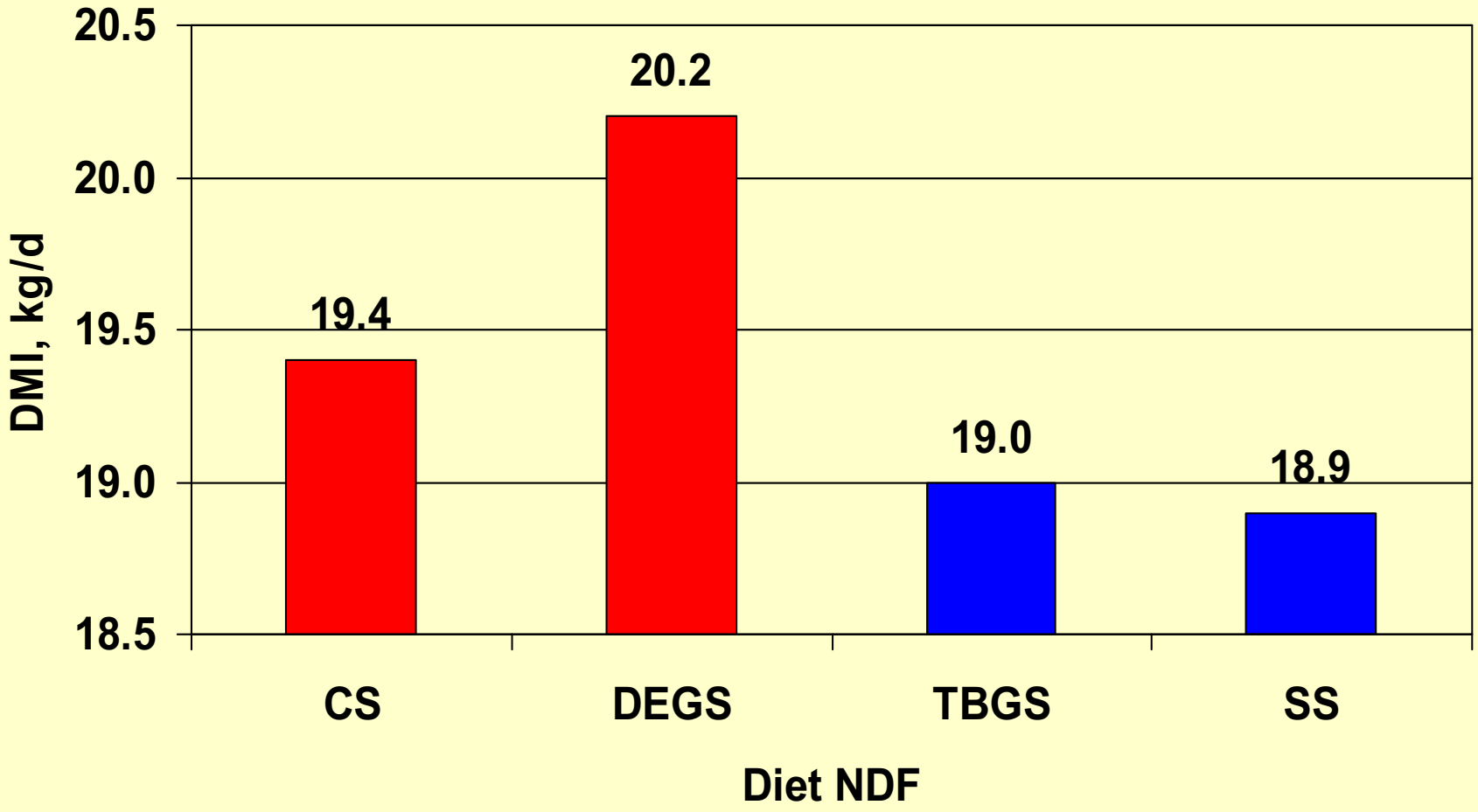


FCM averaged across CS, DEGS, TBGS, SS

Linear effect ($P < 0.01$)

Response to NDF & IVNDFD from diverse forages

Ruiz et al., 1995

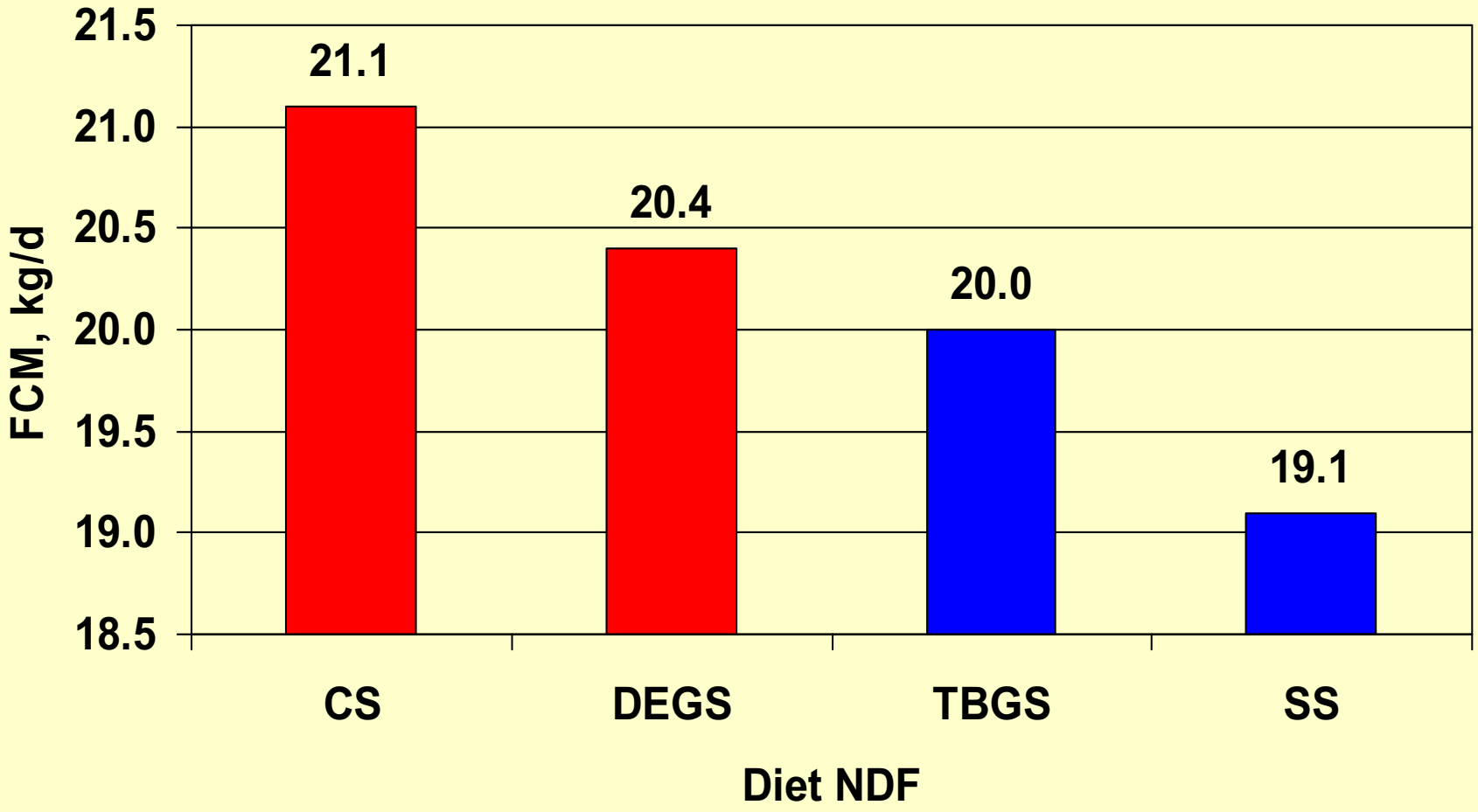


DMI averaged across 31, 35, & 39% diet NDF

CS & DEGS vs. TBGS & SS ($P < 0.05$)

Response to NDF & IVNDFD from diverse forages

Ruiz et al., 1995



FCM averaged across 31, 35, & 39% diet NDF

CS & DEGS vs. TBGS & SS ($P < 0.01$)

Response to BMR sorghum silage IVNDFD

Grant et al., 1995, JDS

	Normal SS	BMR SS	AS	CS
Silage NDF[1]	59%	60%	40%	55%
Diet NDF[2]	42%	40%	30%	40%
DMI, kg/d	20.4[b]	25.3[a]	19.6[b]	23.1[ab]
FCM, kg/d	17.9[b]	26.2[a]	24.6[a]	26.6[a]

[1]SS IVNDFextent 43% for normal vs. 53% for BMR

[2]65% silage diets

Response to BMR sorghum silage ISNDFD

Aydin et al., 1999, JDS

	Normal SS	BMR SS	AS	CS
Silage NDF[1]	52%	50%	39%	41%
Diet NDF[2]	40%	40%	29%	34%
DMI, % of BW	3.5[c]	3.7[b]	4.0[ab]	4.2[a]
FCM, kg/d	20.7[c]	23.7[b]	24.5[b]	29.0[a]

[1]SS ISNDFextent 57% for normal vs. 65% for BMR

[2]65% silage diets

Response to BMR sorghum silage IVNDFD

Aydin et al., 1999, JDS

	Normal SS	BMR SS	CS
Silage NDF[1]	50%	48%	49%
Diet NDF[2]	32%	32%	32%
DMI, kg/d	23.7	25.1	24.8
FCM, kg/d	31.4[b]	33.8[a]	32.4[ab]

[1]SS 30-h IVNDFD 40% for normal vs. 49% for BMR

[2]35% treatment silage & 53% total silage diets

Response to BMR sorghum silage ISNDFD

Oliver et al., 2004, JDS

	Normal SS	BMR-6 SS	BMR-18 SS	CS
Silage NDF	58%	50%	48%	46%
Silage 48-h ISNDFD	56%[b]	63%[a]	61%[a]	59%[a]
Diet NDF[1]	43%	40%	39%	38%
DMI, kg/d	23.2	25.2	23.4	24.3
FCM, kg/d	29.1[b]	33.7[a]	31.2[ab]	33.3[a]

[1]40% treatment silage & 50% total forage diets

Response to wheat silage ISNDFD[1]

Arieli and Adin, 1994, JDS

Item	Early	Late
WS NDF, %	54	53
WS ISNDFD, % of NDF[2]	30	24
DMI, kg/d	23.5	23.1
Milk, kg/d	36.0[a]	32.8[b]
FCM, kg/d	27.5	26.6

[1]168 mid lactation cows fed 35% forage diets

[2]Effective degradability calculated assuming ROP of 4%/h

Response to wheat straw NDF & IVNDFD

Kendall and Combs, 2004, JDS abstr.

	LNDF LNDFD	LNDF HNDFD	HNDF LNDFD	HNDF HNDFD
Diet NDF	28%	28%	32%	32%
Diet IVNDFD	47%	53%	46%	54%
DMI, kg/d	22.8	23.4	21.7	22.3
FCM, kg/d	35.9[b]	37.4[a]	33.0[y]	34.6[x]

- **Diets 8.5% to 16% control or ammoniated wheat straw**
- **41 to 62% NDFD wheat straws**

Response to barley silage IVNDFD[1]

Chow et al., 2006, JDS abstr.

Item	HNDFD	LNDFD
BS NDF, %	53	51
BS IVNDFD, % of NDF[2]	61	52
DMI, kg/d	19.9	20.4
Milk, kg/d	27.1	27.2
BWG, g/d	864[a]	504[b]

[1]30 late lactation cows fed 59% barley silage diets

[2]30h IVNDFD

Summary/Conclusions/Perspectives

- > IVNDFD has been related to ↑ milk production across an array of forages
- Milk production response to IVNDFD thru DMI, not digestibility or energy density
- DMI & milk production responses to IVNDFD > in higher producing cows

Summary/Conclusions/Perspectives

- Benefits of BMR corn & sorghum silages for IVNDFD, DMI, & milk production have been observed consistently
- More IVNDFD/in vivo research needed with legumes & other grasses
  - Single time-point incubations unlikely to predict in vivo differences between legumes & grasses – i.e. rate vs. extent of NDF digestion
- IVNDFD has not been fully exploited in trials attempting to maximize dietary forage or optimize forage mixtures

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