Coping with high corn prices: Low starch diets and lactation performance by dairy cows

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Grain & ingredient cash market comparisons, 2/25/08

Major feed ingredients	Feb. 20	Feb. 13	6 months ago	Year ago
Corn No. 2, Chicago, bu.				
Processor bid*	5.07A	4.93A	3.84A	3.58A
Terminal bid*	4.97A	4.81	3.71A	3.44A
Milo, Kansas City, cwt.	9.00	8.54	6.42	5.80
Soybeans, Chicago, bu.				
Processor Bid	13.59A	13.26A	7.86A	6.22A
Soybean Meal, 48% Decatur Bid	342.80A	342.90A	228.20A	177.70A
Cottonseed Meal, Memphis, ton	270.00	285.00	125.00	155.00
Linseed Meal, Solvent, Minneapolis	245.00	245.00	140.00	132.00
Meat and Bone Meal, Chicago, ton	413.00	398.00	245.00	205.00
Fish Meal, Menhaden, Atlanta, ton	N/A	N/A	N/A	N/A
Corn Gluten Meal, 60%, Chicago, ton	560.00	565.00	358.00	312.00
Brewers Dried Grains, Chicago, ton	N/A	N/A	100.00	98.00
17% Dehy. Alfalfa Pellets, KC, ton	227.00	227.00	213.00	192.00
Millfeeds, Midds, Minneapolis, ton	180.00	175.00	60.00	120.00
Molasses, Cane, New Orleans, ton	105.00	105.00	115.00	120.00
Dried Citrus Pulp, Atlanta, ton	206.00	206.00	179.00	147.00
Whey, Whole, Chicago, cwt.	25.25	25.87	73.00	41.50
Rolled Oats, Minneapolis, ton	522.00	512.00	371.00	325.00
Barley, Los Angeles, cwt.	13.80	13.80	9.75	9.80
Feeding Wheat, Kansas City, bu.	10.73	10.84	6.68	4.81

* Chicago corn and soybean prices for latest and previous week are the middle of the range of to-arrive bids; soybean meal prices are midrange of processor quotes. Chicago corn and soybean prices provided by USDA Market News. Six months, year ago comparisons are all spot cash. Based on prices reported by Feedstuffs' market reporters.

A: average

N/A: not available

MARKETS

Corn	543-2
Soybeans	1498-4
Soybean Meal	373.5
Oats	414-4
KC Wheat	1235-0
Live Cattle	94.75
Feeder Cattle	104.65
Lean Hogs	61.25
CME Milk	18.05

Data Provided By Barchart.com

Feed ingredient market comparison
Livestock & poultry market comparison
USDA Feed Grains Database

Starch content of diets for lactating dairy cows?

	n	Average	Min	Max
Shaver et al., 2008 ≥13,650 kg RHA herds	9	27%	25%	30%
Bucholtz, 2006 ≥13,650 kg RHA herds	18	26%	24%	30%
Staples, 2007	Suggested 24% - 26% starch diets as "ideal" from summary of research literature			

Can we lower the starch content of diets for lactating dairy cows and how low can we go?

Impact of Reducing C:F Ratio

C:F Ratio Trial[1,2]

Tessman et al., 1991, JDS

(0-12 wk, 13-26 wk, 27-44 wk of lactation)

Item	(62,52,32) **46% C**	(52,42,22) **36% C**	(42,32,12) **26% C**	(32,12,2) **14% C**	**2% C**

[1]44 multiparous cows over 44 wk lactation study

[2]AS NDF = 44 ± 5; AS ADL = 6.8 ± 1

Early/Mid Lactation Diet Nutrient Composition--C:F Ratio Trial

Tessman et al., 1991, JDS

DM basis	57% C	47% C	37% C	22% C	2% C
Starch	29%	25%	21%	16%	6%
Forage NDF	19%	23%	28%	34%	43%

Response to C:F Ratio

Tessman et al., 1991, JDS

	46% C	36% C	26% C	14% C	2% C
DMI, kg/d	21.6^{ab}	22.5^{a}	21.1^{ab}	20.6^{b}	19.0^{c}
305-d Milk, kg	8641^{ab}	8315^{a}	7453^{bc}	6849^{cd}	6000^{d}
Fat %	3.37^{b}	3.76^{a}	3.63^{ab}	3.69^{a}	3.77^{a}
Protein %	3.20^{ab}	3.24^{a}	3.17^{ab}	3.11^{ab}	3.06^{b}
Dry-Off BCS	3.7	3.5	3.5	2.9	2.9

Lactation Income Over Feed Cost—C:F Ratio Trial

Tessman et al., 1991, JDS

	46% C	36% C	26% C	14% C	2% C
Milk Value, $[1]					
TP @ $4.50/kg	2591	2606	2283	2092	1833
TP @ $9.00/kg	3835	3818	3346	3050	2660
Feed Cost, $[2]	1537	1509	1315	1298	966
IOFC, $	1054 to 2299	1096 to 2308	967 to 2031	794 to 1752	868 to 1694

[1]Milk Fat=$3.00/kg, OS=$0.45/kg, & Premiums=$0.03/kg milk

[2]AS=$130/ton DM, Corn=$5.50/bu., & SBM44=$380/ton

Early/Mid Lactation Diet Nutrient Composition--C:F Ratio Trial

Tessman et al., 1991, JDS

DM basis	57% C	47% C	37% C	22% C	2% C
Starch	29%	25%	21%	16%	6%
Forage NDF	19%	23%	28%	34%	43%

Trials on partial replacement of starch from corn grain with digestible NDF or pectin from byproduct feeds

Diet Composition

Trial	Ingredients	Nutrients
MSU	Beet Pulp vs. HM Corn 0, 6, 12, 24% DBP	18% CP 17% FNDF
USDFRC	Citrus Pulp vs. Dry Corn 0 & 19% DCP	19% CP 22% FNDF
Univ. of IL	Soyhulls vs. Dry Corn 0, 10, 20, 30, 40% SH	16% CP 19% FNDF
Cornell Univ.	Soyhulls vs. HM Corn 0 & 14% SH	18-19% CP 21% FNDF
UW-Madison	Mixture of 0-10% WM, 3-20% BDG, 0-9% SH vs. Dry Corn	19-20% CP 21% FNDF

Diet Starch vs. DMI

Trial	Ingredients	Diet Starch %	% of Control
MSU	Beet Pulp vs. HM Corn	31% vs. 35% 27% 18%	101% 101% 92%* (L)
USDFRC	Citrus Pulp vs. Dry Corn	20% vs. 31%	92%*
Univ. of IL	Soyhulls vs. Dry Corn	23% vs. 28% 17% 13% 7%	104% 103% 96% 95%* (L)
Cornell Univ.	Soyhulls vs. HM Corn	16% vs. 25%	109%
UW-Madison	Mixture of WM, BDG, & SH vs. Dry Corn	26% vs. 30% 21% 15%	99% 97% 94%* (L)

Diet Starch vs. Milk Yield

Trial	Ingredients	Diet Starch %	% of Control
MSU	Beet Pulp vs. HM Corn	31% vs. 35% 27% 18%	101% 99% 97%
USDFRC	Citrus Pulp vs. Dry Corn	20% vs. 31%	89%*
Univ. of IL	Soyhulls vs. Dry Corn	23% vs. 28% 17% 13% 7%	99% 101% 99% 96%*
Cornell Univ.	Soyhulls vs. HM Corn	16% vs. 25%	103%
UW-Madison	Mixture of WM, BDG, & SH vs. Dry Corn	26% vs. 30% 21% 15%	99% 99% 98%

Diet Starch vs. FCM

Trial	Ingredients	Diet Starch %	% of Control
MSU	Beet Pulp vs. HM Corn	31% vs. 35% 27% 18%	103% 102% 98%* (Q)
USDFRC	Citrus Pulp vs. Dry Corn	20% vs. 31%	86%*
Univ. of IL	Soyhulls vs. Dry Corn	23% vs. 28% 17% 13% 7%	100% 104% 106% 102%
Cornell Univ.	Soyhulls vs. HM Corn	16% vs. 25%	102%
UW-Madison	Mixture of WM, BDG, & SH vs. Dry Corn	26% vs. 30% 21% 15%	100% 101% 100%

Diet Starch vs. FCM/DMI

Trial	Ingredients	Diet Starch %	% of Control
MSU	Beet Pulp vs. HM Corn	31% vs. 35% 27% 18%	102% 101% 107%* (L)
USDFRC	Citrus Pulp vs. Dry Corn	20% vs. 31%	94%
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Cornell Univ.	Soyhulls vs. HM Corn	16% vs. 25%	94%
UW-Madison	Mixture of WM, BDG, & SH vs. Dry Corn	26% vs. 30% 21% 15%	100% 102% 105%

Diet Starch vs. Milk Fat %

Trial	Ingredients	Diet Starch %	% of Control
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USDFRC	Citrus Pulp vs. Dry Corn	20% vs. 31%	105%
Univ. of IL	Soyhulls vs. Dry Corn	23% vs. 28% 17% 13% 7%	100% 102% 109% 109%* & (L)
Cornell Univ.	Soyhulls vs. HM Corn	16% vs. 25%	99%
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Univ. of IL	Soyhulls vs. Dry Corn	23% vs. 28% 17% 13% 7%	101% 107% 112% 109%* (L)
Cornell Univ.	Soyhulls vs. HM Corn	16% vs. 25%	102%
UW-Madison	Mixture of WM, BDG, & SH vs. Dry Corn	26% vs. 30% 21% 15%	102% 103% 102%

Diet Starch vs. Milk Protein %

Trial	Ingredients	Diet Starch %	% of Control
MSU	Beet Pulp vs. HM Corn	31% vs. 35% 27% 18%	100% 100% 97%
USDFRC	Citrus Pulp vs. Dry Corn	20% vs. 31%	96%
Univ. of IL	Soyhulls vs. Dry Corn	23% vs. 28% 17% 13% 7%	99% 100% 98% 99%
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Cornell Univ.	Soyhulls vs. HM Corn	16% vs. 25%	101%
UW-Madison	Mixture of WM, BDG, & SH vs. Dry Corn	26% vs. 30% 21% 15%	98% 98% 94%* (L)

Staples (2007) CGF Trial Summary

- 14 Trials with lactating dairy cows
- CGF partially replaced grains, protein meals or forages
- Dietary starch concentrations ranged across the trials from 15% to 40%
- Concluded that diets containing 21% starch (DM basis) acceptable

Trials on partial replacement of corn starch with sugars

Diet Composition

Trial	Ingredients	Nutrients
USDFRC1 Trial1	Dried Molasses vs. HM Corn 0, 4, 8, 12% Mol.	18% CP 23% FNDF 3% - 7% sugar
USDFRC1 Trial2	Liquid Molasses vs. HM Corn 0, 3, 6, 9% Mol.	16% CP 21% FNDF 3% - 10% sugar
USDFRC2	Sucrose vs. HM Corn & Starch 0, 2.5, 5, 7.5% Suc.	17% CP 23% FNDF 3% - 11% sugar

Diet Starch vs. DMI

Trial	Ingredients	Diet Starch %	% of Control
USDFRC1 Trial1	Dried Molasses vs. HM Corn 0, 4, 8, 12% Mol.	28% vs. 32% 25% 23%	102% 104% 103%* (L)
USDFRC1 Trial2	Liquid Molasses vs. HM Corn 0, 3, 6, 9% Mol.	29% vs. 31% 28% 26%	111% 103% 106%* (C)
USDFRC2	Sucrose vs. HM Corn & Starch 0, 2.5, 5, 7.5% Suc.	29% vs. 32% 26% 23%	105% 106% 106%* (L)

Diet Starch vs. Milk Yield

Trial	Ingredients	Diet Starch %	% of Control
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Diet Starch vs. FCM

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	0, 4, 8, 12% Mol.	25%	102%
		23%	97%* (Q)
USDFRC1 Trial2	Liquid Molasses vs. HM Corn	29% vs. 31%	104%
	0, 3, 6, 9% Mol.	28%	101%
		26%	97* (L)
USDFRC2	Sucrose vs. HM Corn & Starch	29% vs. 32%	104%
	0, 2.5, 5, 7.5% Suc.	26%	103%
		23%	101%

Diet Starch vs. FCM/DMI

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USDFRC1 Trial2	Liquid Molasses vs. HM Corn 0, 3, 6, 9% Mol.	29% vs. 31% 28% 26%	92% 95% 90%* (L)
USDFRC2	Sucrose vs. HM Corn & Starch 0, 2.5, 5, 7.5% Suc.	29% vs. 32% 26% 23%	100% 102% 101%

Diet Starch vs. Milk Fat %

Trial	Ingredients	Diet Starch %	% of Control
USDFRC1 Trial1	Dried Molasses vs. HM Corn	28% vs. 32%	107%
	0, 4, 8, 12% Mol.	25%	104%
		23%	102%* (Q)
USDFRC1 Trial2	Liquid Molasses vs. HM Corn	29% vs. 31%	102%
	0, 3, 6, 9% Mol.	28%	97%
		26%	101%
USDFRC2	Sucrose vs. HM Corn & Starch	29% vs. 32%	100%
	0, 2.5, 5, 7.5% Suc.	26%	107%
		23%	109%* (L)

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		26%	92%
USDFRC2	Sucrose vs. HM Corn & Starch	29% vs. 32%	104%
	0, 2.5, 5, 7.5% Suc.	26%	112%
		23%	110%* (L)

Diet Starch vs. Milk Protein %

Trial	Ingredients	Diet Starch %	% of Control
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	0, 3, 6, 9% Mol.	28%	104%
		26%	98%* (Q)
USDFRC2	Sucrose vs. HM Corn & Starch	29% vs. 32%	103%
	0, 2.5, 5, 7.5% Suc.	26%	104%
		23%	103%

Addition of Sugars to TMR

- Reduced dietary starch concentrations 5%-units on average—Thus can reduce corn in high-starch diets or increase "corn equivalency" of low-starch diets by about 7%-units

- Sugar options
  - Molasses, LFS, Sucrose, Bakery waste, Whey, Beet or citrus pulp
  - Glycerol?
  - Evaluate prices relative to starch or corn

Impact of corn silage in the forage mixture on dietary starch content

Potential to increase starch in low-starch diets or reduce corn in high-starch diets by increasing the proportion of corn silage in the forage mixture

Proportion of corn silage in forage DM	% unit Starch increase[1]	% unit Corn reduction[1]
50% vs. 25%	3%	4.5%
75% vs. 25%	6%	9%

[1]Assumes 25%-units more Starch in CS than AS on average (Dairyland Labs, 2007; NRC, 2001)

Starch content of corn silage

Dairyland Labs, Arcadia, WI

		Starch % (of DM)	
Year	n	Mean	Std. Deviation
2006	11,000	30%	6%
2005	14,000	30%	7%
2004	13,000	29%	7%
2003	13,000	29%	7%
2002	12,000	30%	8%

Impact of corn silage starch content on starch content of low-starch diets or corn content of high-starch diets

Corn silage starch content	% unit Starch increase[1]	% unit Corn reduction[1]
29% vs. 22%	2.5%	4%
36% vs. 22%	5%	7%

[1]Assumes 35% corn silage in diet DM

Impact of starch digestibility

Starch Digestibility

- High-Moisture Corn > Dry Corn
- High-Moisture Corn; > with > moisture content
- Ground > Rolled Corn; > with > fineness of grind
- Steam-Flaked Corn > Dry Rolled; Varies with flake density
- Floury Corn > Vitreous Corn
- Rolled > Unrolled Corn Silage; varies by roll setting
- Early > Late Maturity Corn Silage

➢If low-starch diets are fed and the cost of starch is high, then it seems logical that the starch should be highly digestible

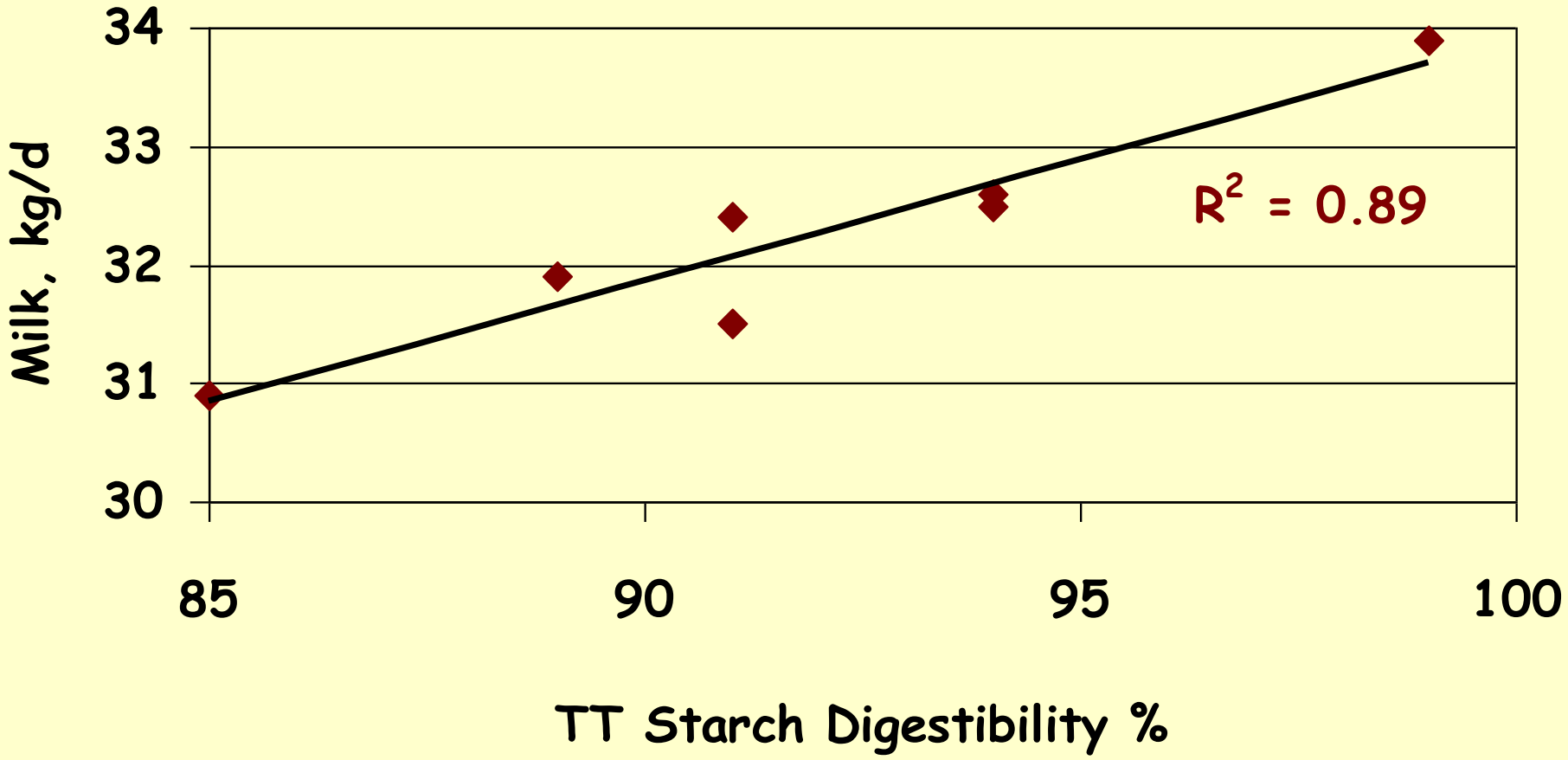
Diet Starch Digestibility by Corn Source

Firkins et al., JAS, 2001

Corn Source	# of Trials	Diet TT Starch Digestibility, %
Dry, cracked/rolled	9	85
Steam rolled	10	89
Dry, ground	13	91
Dry, fine ground	3	91
Steam flaked	10	94
High-moisture, rolled	3	94
High-moisture, ground	2	99

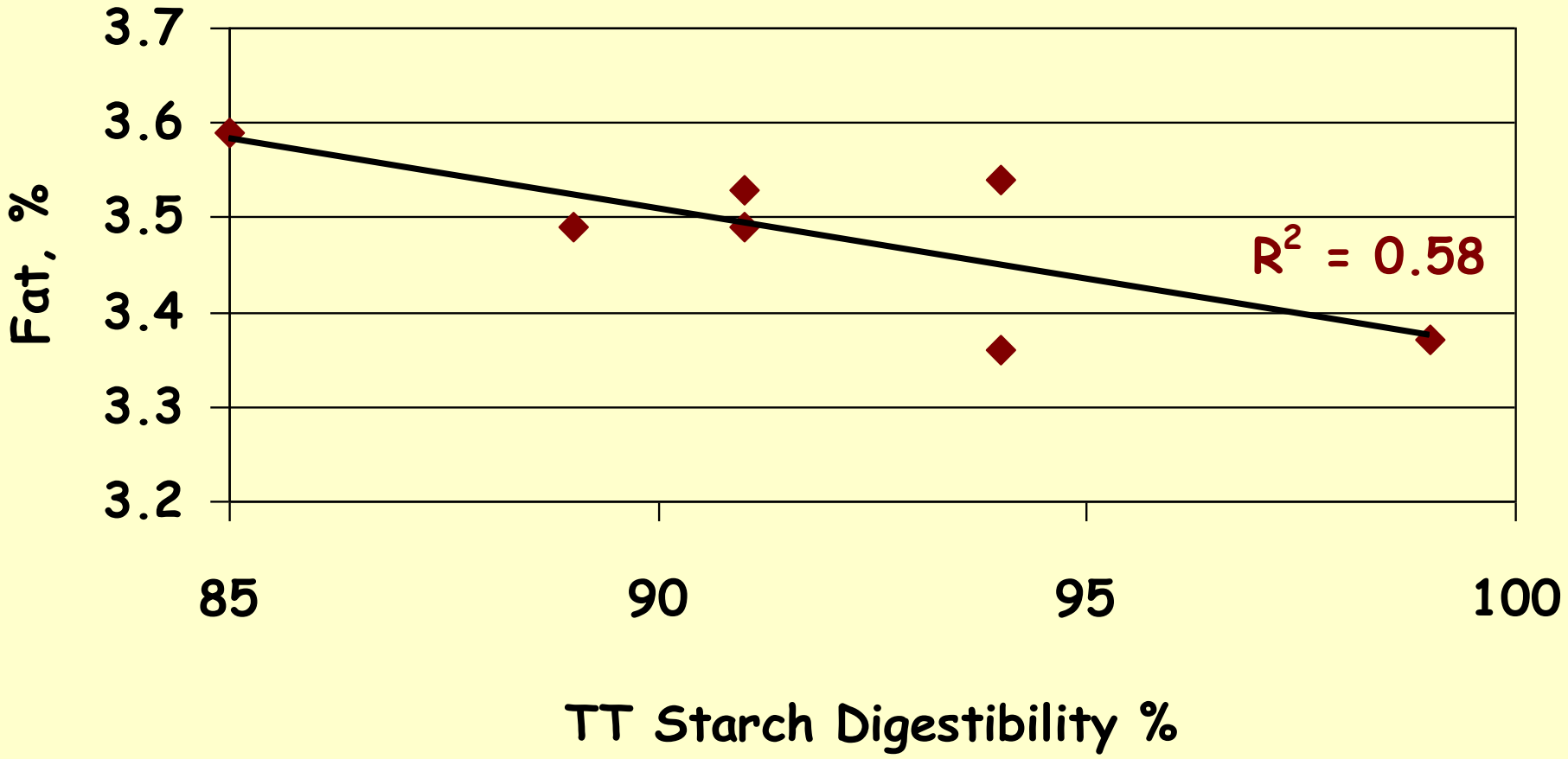
Diet Starch Digestibility vs. Milk Yield

Firkins et al., JAS, 2001



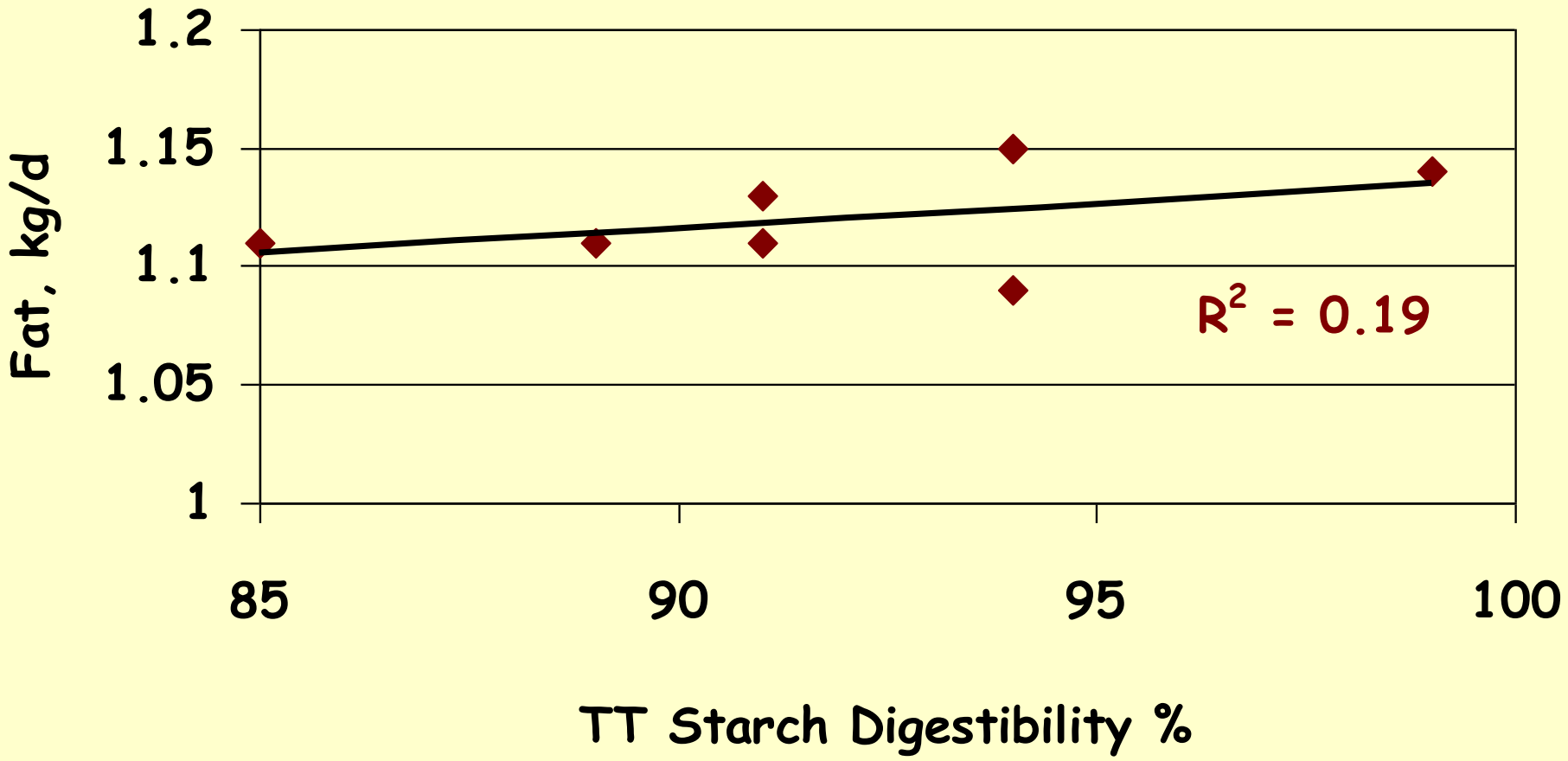
Diet Starch Digestibility vs. Milk Fat %

Firkins et al., JAS, 2001



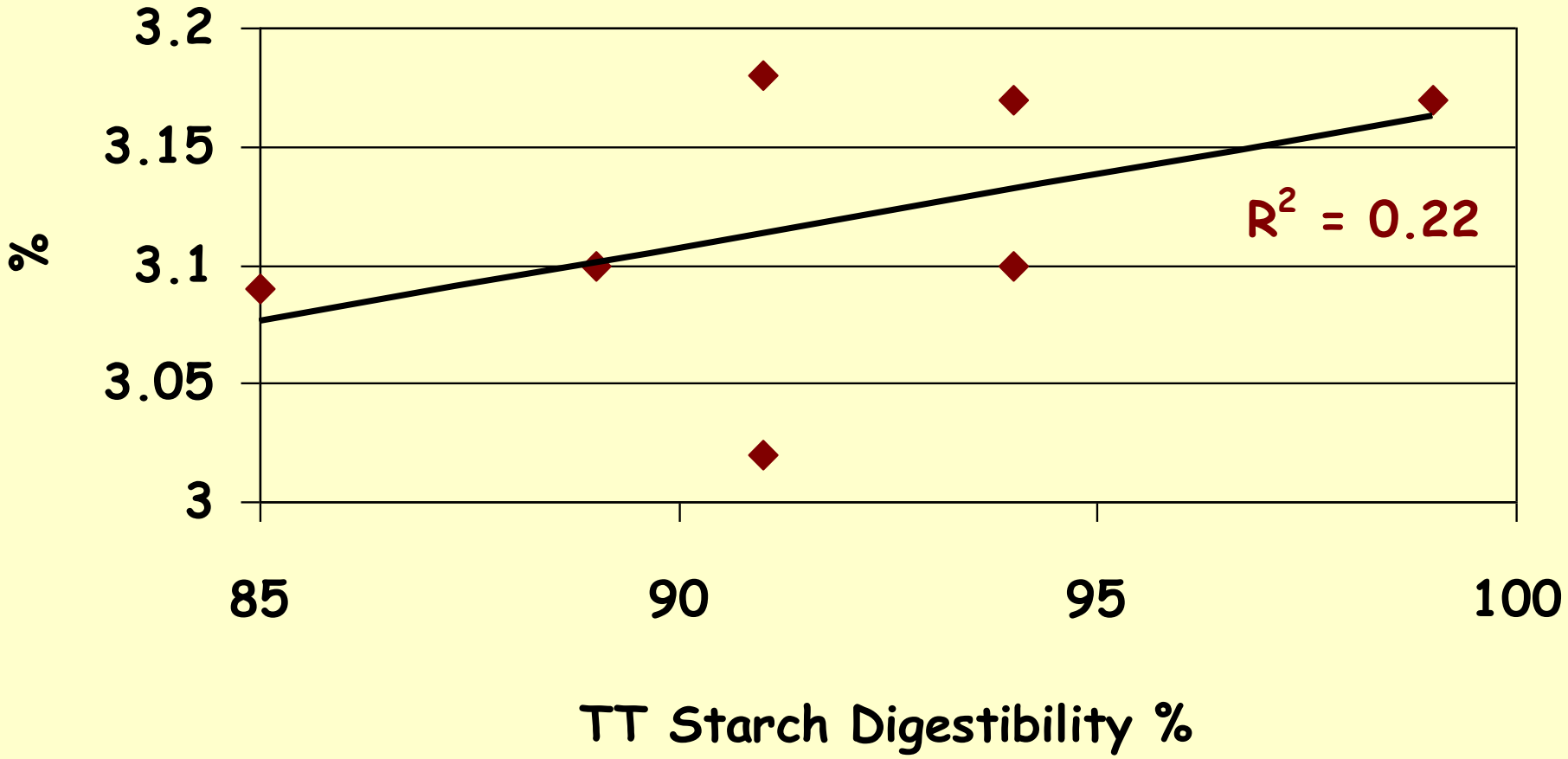
Diet Starch Digestibility vs. Fat Yield

Firkins et al., JAS, 2001



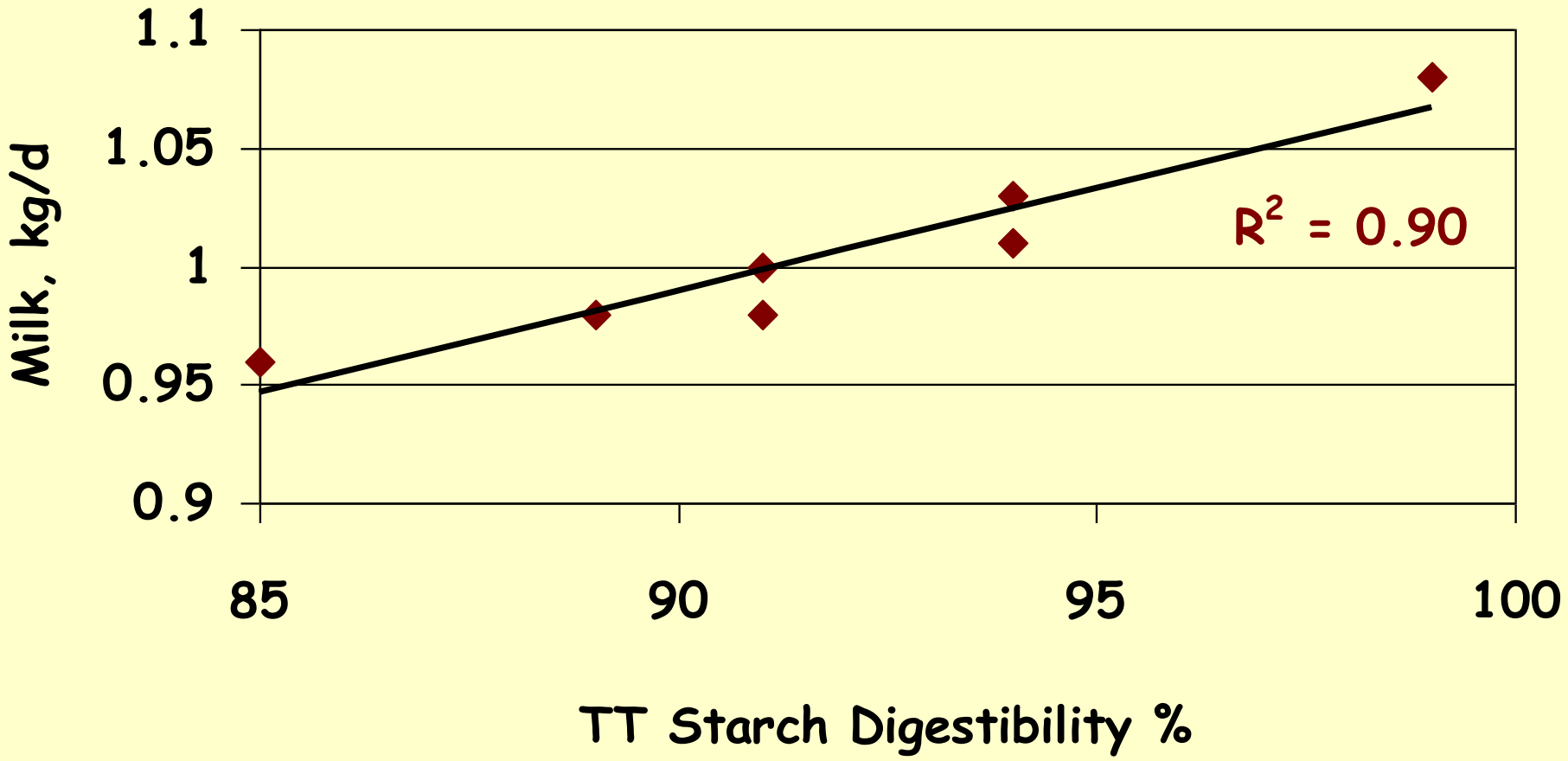
Diet Starch Digestibility vs. Milk Protein%

Firkins et al., JAS, 2001



Diet Starch Digestibility vs. Protein Yield

Firkins et al., JAS, 2001



Effect of processing on site of digestion of corn starch

Owens et al., 1986

	Dry Corn		High Moisture Corn
	Cracked	Ground	
	- - - - Proportion of Starch Digestion - - - -		
Ruminal	69%	78%	86%
Post-Ruminal	21%	18%	7%
Total Tract	90%	96%	93%

Rumensin® and dietary starch content

Estimated Increase in Diet Energy Density with Rumensin®

Rumensin, g/ton	Calculated Energy Density (Mcal/lb)[a]
0	0.69
7	0.70
15	0.71
22	0.72

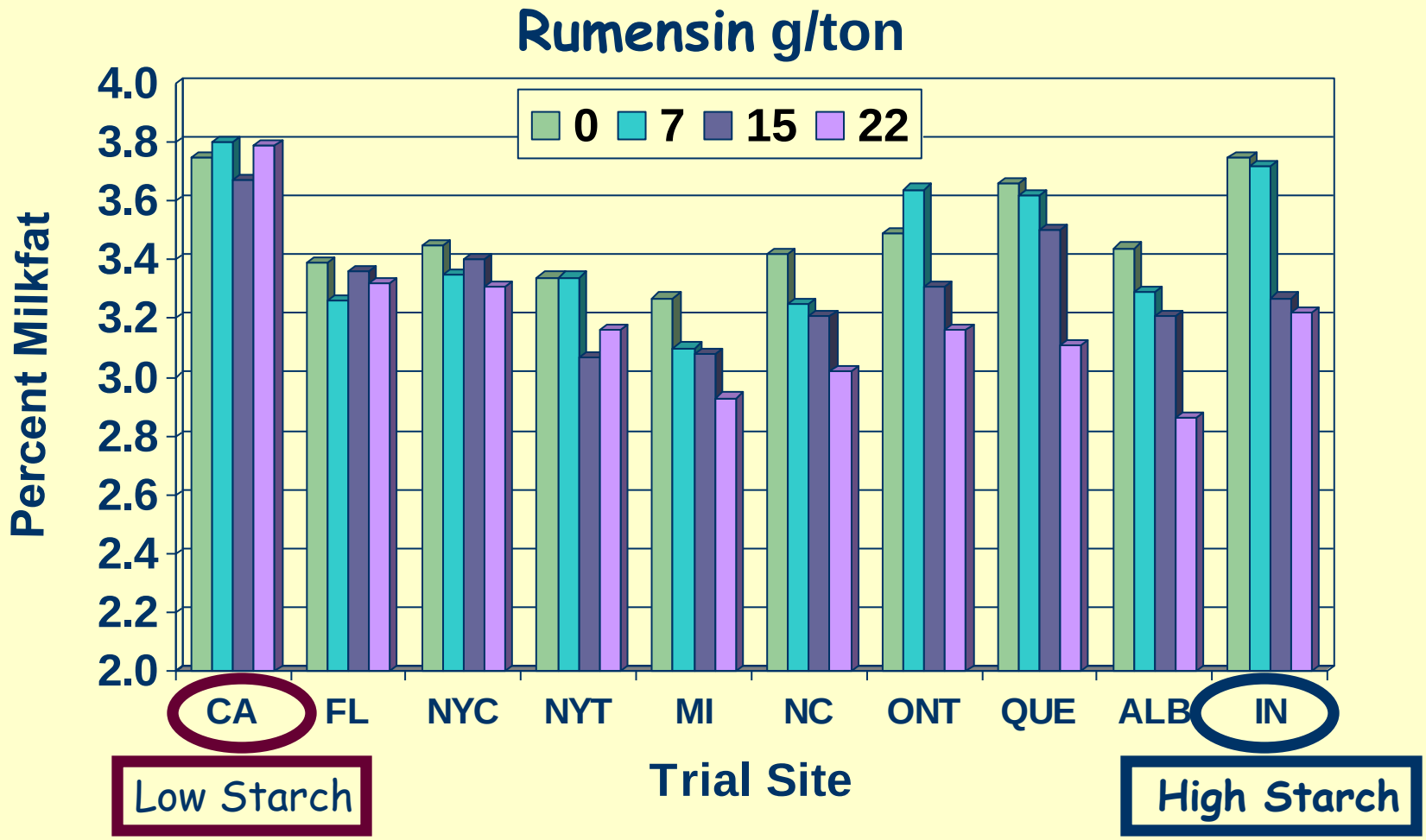
[a] Source: Elvin Thomas from Elanco's 9-trial summary

Elanco Calculation of Corn Energy Equivalency

- The Rumensin® increase in energy was equivalent to feeding 0.45 to 0.91 kg of corn
- Rumensin® can allow the feeding of less grain to obtain similar energy from the diet

Source: Elvin Thomas, Elanco

Effect of Rumensin® Dose on Milk Fat Percent by Trial Site



Conclusions

- Lactation performance was reduced for 18% & 20% starch diets formulated using beet pulp & citrus pulp, respectively, to partially replace corn grain
- Lactation performance was not reduced for 16%-17% starch diets formulated using soyhulls to partially replace corn grain
- 21% starch diets appear acceptable when high fiber, moderate protein byproduct feeds partially replace corn grain & protein supplement

Conclusions

- The following can reduce the corn needed in high-starch diets or increase the "corn equivalency" of low-starch diets:
  - A higher proportion of corn silage in the forage mix
  - Feeding high-starch corn silage
  - Supplementing sugars
  - Use of Rumensin®
- The starch in low-starch diets should be highly digestible