High moisture corn in dairy rations

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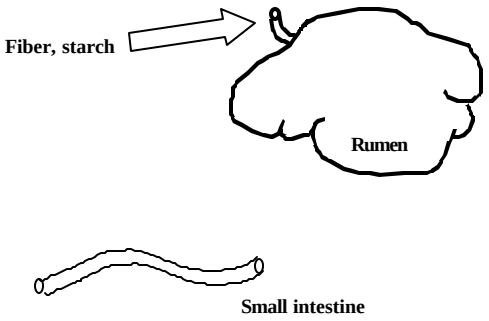
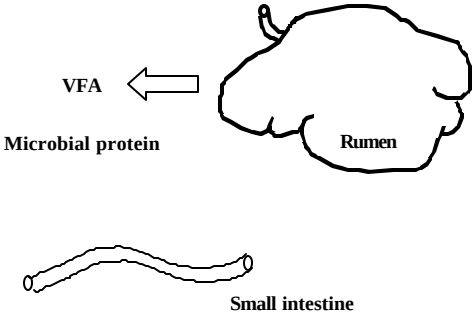
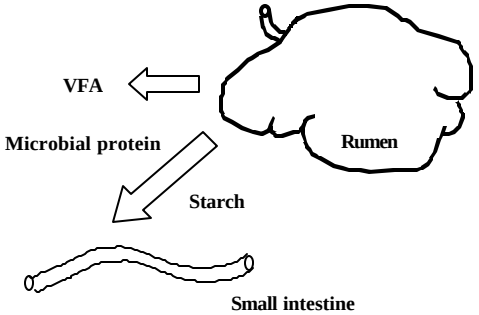
Nutrient supply



Nutrient supply



Nutrient supply



Starch degradability

Degradability	Grain	Moisture	Processing
High	Wheat	HM / SF	Ground
↓	Barley	↓	↓
	Oats		Cracked/rolled
	Corn		↓
Low	Sorghum	Dry	Whole

Starch digestion & performance

Study	Treatment	DMI	Milk
McCarthy et al., 1989	Barley vs. corn	⇩	⇩
Aldrich et al., 1993	HM vs. DG corn	⇩	⇧
Moore et al., 1992	SF vs. DR sorghum	⇔	⇧
Chen et al., 1995	SF vs. DR sorghum	⇩	⇔
Lykos et al., 1997	HM vs. Cracked corn		
Oliviera et al., 1993	SF vs. DR sorghum		
Mitzner et al., 1994	Corn vs. sorghum		

Objective

- Results of previous studies often confounded with starch source, dietary NDF, dietary CP, etc.
- Evaluate the effects of corn grain moisture and processing on
  - site of starch digestion,
  - energy metabolism, and
  - milk production of early lactation cows

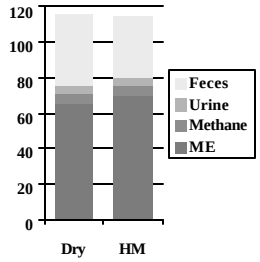
Experimental approach

- High moisture vs. dry corn, ground vs. rolled 2x2 factorial arrangement of treatments
- Early blood, wilted alfalfa silage, lignosulfonate treated SBM (SoyPass™)
- 45% forage, 35% starch, 27% NDF, 20% CP
- Fed for ad libitum intake every 12 hours

Experimental approach

- **Energy metabolism**
  - **8 early lactation multiparous cows in open circuit respiration chambers**
- **Digestion**
  - **6 early lactation multiparous cows, ruminally-, duodenally-, and ileally-cannulated**
- **Production**
  - **34 early lactation cows (17 multiparous), commercial conditions, Calan gates**

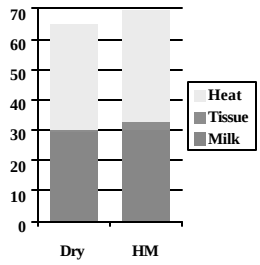
Energy losses: GE ⇨ME



- **Similar gross energy (GE) intake**
- **HM corn decreased fecal energy vs. dry corn**
- **No effect on urinary or methane energy**
- **HM corn diets had 7% more ME than dry corn diets**

Wilkerson et al., 1997

Energy losses: ME ⇨NEl



- **HM corn increased heat production vs. dry corn**
- **HM corn increased tissue energy**
- **Milk energy output similar**

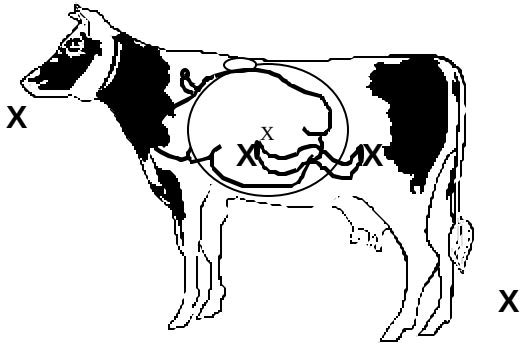
Wilkerson et al., 1997

Energy metabolism

	Dry		High moisture		*P* <		
	Ground	Rolled	Ground	Rolled	M	P	MxP
DE, Mcal/kg diet	3.10	3.04	3.41	3.27	.01	.05	NS
ME, Mcal/kg diet	2.68	2.63	2.98	2.84	.01	.05	NS
NEl, Mcal/kg diet	1.63	1.65	1.84	1.72	.01	NS	NS
NEl, Mcal/kg grain	1.96	2.00	2.42	2.16			

Wilkerson et al., 1997

Digestion study



Starch digestion

	Dry		High moisture		*P* <		
	Ground	Rolled	Ground	Rolled	M	P	MxP
Rumen starch dig., %	60.9	.	86.8	81.2	.05	NS	NS
Duod starch flow, g/d	3109	.	1138	1578	.01	NS	NS
Ileal starch flow, g/d	2696	.	470	575	.01	NS	NS
SI starch dis., g/d	412	.	668	1003	.05	NS	NS

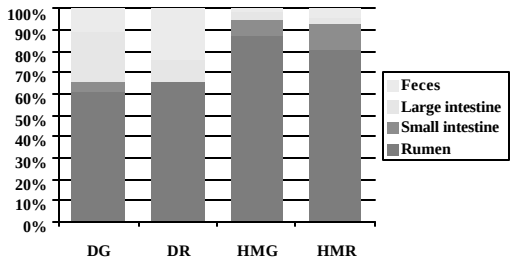
Knowlton et al., 1998

Starch digestion

	Dry		High moisture		*P* <		
	Ground	Rolled	Ground	Rolled	M	P	MxP
Ileal starch flow, g/d	2696	2858	470	575	.01	NS	NS
Fecal starch flow, g/d	878	1986	147	377	.01	.05	NS
LI starch dis., g/d	1819	872	323	198	.01	.05	NS
Total tract starch dig., %	88.9	76.4	98.2	95.7	.01	.01	.10

Knowlton et al., 1998

Site of starch digestion



Knowlton et al., 1998

Intestinal starch digestion

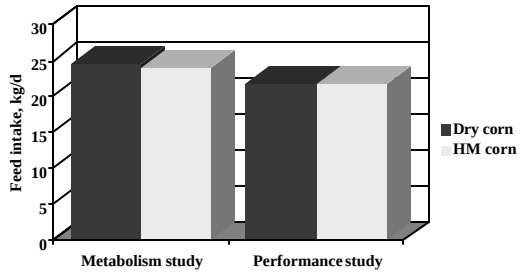
	Starch		Dextrin	
	Small intestinal disappearance			
Infused	g/h	%	g/h	%
0 g/h				
20 g/h	17.8	89	18.6	93
40 g/h	28.3	71	34.2	86
60 g/h	34.8	58	49	81

Kreikemeier et al., 1991

SI starch digestion

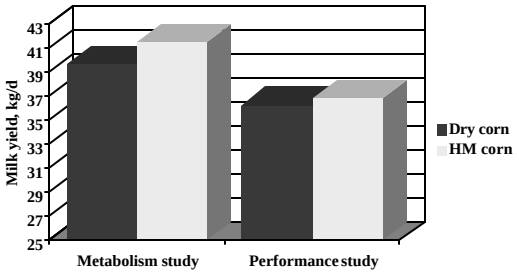
- **Advantageous?**
  - **Energetic efficiency**
  - **Avoid intake depression**
- **But . . .**
  - **Starch has limited small intestinal digestibility**
  - **Mixed effects on performance**
- **It happens. Maximize its availability.**
  - **Structure may be more important than quantity**
  - **Gelatinization of starch granule, partial hydrolysis with high moisture grains, steam flaked?**

Feed intake



Wilkerson et al., 1997; Knowlton et al., 1998

Milk yield



Wilkerson et al., 1997; Knowlton et al., 1998

Conclusions

- NEl of HM corn was 16% greater than dry corn
- This increase in NEl is due to increased starch digestion in the rumen AND the small intestine, decreasing fecal losses
- Decreased total tract digestion, NEl, and milk yield make dry rolled corn inappropriate for high producing cows

Conclusions

- On high starch diets, significant starch flow to the SI occurs.
  - Maximize digestibility of this starch with same techniques that maximize ruminal digestion
- Post-ruminal starch digestion does not necessarily equal small intestinal digestion
- Optimal site of starch digestion?
  - SI digestibility was always less than ruminal digestibility
  - losses from SI likely offset theoretical gains in efficiency

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Performance

	Dry		High moisture		*P* <		
	Ground	Rolled	Ground	Rolled	M	P	MxP
DMI, kg/d							
Metabolism	24.9	24.0	24.1	23.7	NS	NS	NS
Performance	22.9	20.7	22.0	21.8	NS	.05	.05
Milk yield, kg/d							
Metabolism	40.5	38.9	43.1	40.2	.10	.05	NS
Performance	37.6	35.1	37.8	35.9	NS	.10	NS

Wilkerson et al., 1997; Knowlton et al., 1998

Nitrogen digestion

	Dry		High moisture				
	Ground	Rolled	Ground	Rolled	*P* <		
N intake, g/d	782	788	855	831	.05	NS	NS
Duodenal N, g/d							
Microbial	443	359	385	471	NS	NS	.12
Total	713	696	704	805	NS	NS	NS
Fecal N, g/d	336	334	292	313	.17	NS	NS
Total tract N dig., %	57.5	57.3	65.4	62.0	.01	NS	NS

Rumen fermentation

	Dry		High moisture				
	Ground	Rolled	Ground	Rolled	*P* <		
Rumen fluid pH	6.14	6.27	6.14	6.16	NS	NS	NS
Acetate, mol %	62.9	62.1	60.8	61.2	.10	NS	NS
Propionate, mol%	21.1	20.7	22.7	22.4	NS	NS	NS
Butyrate, mol %	10.1	10.7	9.81	9.91	NS	NS	NS
Total VFA, mol	105	111	115	124	.09	NS	NS
A:P ratio	3.06	3.02	2.78	2.79	.13	NS	NS

Diet composition

	Dry corn		High moisture corn	
Nutrient	Ground	Rolled	Ground	Rolled
NDF	28.0	27.7	26.8	26.9
ADF	20.2	20.2	20.2	20.1
Starch	34.1	34.4	36.0	35.8
CP	20.3	20.2	20.4	20.3