UW-Feed Grain Evaluation System
Marshfield Soil and Forage Analysis Laboratory

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I-Introduction:

Management practices, such as grinding, (Remond et al., 2004; Theurer, 1986), steam flaking (Callison et al., 2001), ensiling (Oba and Allen, 2002), or type of endosperm (Lopes et al., 2009; Allen et al., 2008), have been demonstrated to alter in vivo starch digestion and lactation performance of dairy cows. Despite knowledge (Firkins et al., 2001) of factors that influence feed grain utilization by dairy cows, feed and forage testing laboratories have been challenged to offer a systematic method of evaluating feed grains. The UW-Feed Grain Evaluation System was developed to provide a simple basic evaluation system to evaluate feed grains fed to dairy cattle.

II-Objective:

To encourage Wisconsin dairy nutrition consultants and dairy producers to evaluate feed grains for the principal components which influence feed grain digestion and animal performance.

III-Principal Components of Feed Grain Utilization by Dairy Cows:

The principle components of feed grains which have been demonstrated to alter feed grain digestibility and performance of lactating dairy cows are particle size, moisture content (fermentation) and vitreousness (prolamin) of the endosperm. Capstone research used to develop the UW-Feed Grain Evaluation System, which defines the effects of principal components on in vivo total tract starch digestion (**TTSD**) in lactating dairy cows is presented in Table 1.

IV-Required Laboratory Measurements

Nutrient	**Abbreviation**	**Unit**	**Method/Notation**
A-Dry Matter	DM	% as fed	AOAC, 1990
B-Crude Protein	CP	% DM	AOAC, 1990
C-Prolamin	na	% DM	Larson and Hoffman, 2008
D-Prolamin	na	% Starch	(C/E)*100
E- Starch	na	% DM	Erhman, 1996
F- Neutral Detergent Fiber	NDF	% DM	Goering and VanSoest, 1970 Mertens, 1992
G-Neutral Detergent Fiber-Protein	NDFCP	% DM	Book value of 0.7 acceptable
H- Fat	EE	% DM	AOAC, 1990 *or* Book value of 4.2 acceptable
I-Ash	na	% DM	AOAC, 1990
J-Mean Particle Size	MPS	microns	Baker and Herrman, 2002
K-Non-Fiber Carbohydrate	NFC	% DM	100- ((CP+(NDF-NDFCP)+Fat+Ash))

L-Degree of Starch Access DSA % Starch Blasel et al, 2006

V- Feed Grain Calculations: *(See Figures 1 and 2.)*

Estimated Total Tract Starch Digestibility (eTTSD):

High Moisture Grains: (if moisture > 22.5 %)

eTTSD,% Starch = ((99.72+(-.00282*MPS,*u*m))+((5.97-Prolamin,% of Starch)*(0.86))

Where Prolamin,% Starch =

Corn Feed Grains	Analytical result of Larson and Hoffman, 2008
Small Grains	(CP, %DM*0.3)/(Starch,%DM/100) Lasztity, 1984.
Milo/Sorghum	(CP, %DM*0.6)/(Starch,%DM/100) Lasztity, 1984.

Dry Grains: (if moisture < 22.5 %)

eTTSD,% Starch = ((97.67+(-.00514*MPS,*u*m))+((5.97-Prolamin,% of Starch)*(0.86))

Where Prolamin,% Starch =

Corn Feed Grains	Analytical result of Larson and Hoffman, 2008
Small Grains	(CP, %DM*0.3)/(Starch,%DM/100) Lasztity, 1984.
Milo/Sorghum	(CP, %DM*0.6)/(Starch,%DM/100) Lasztity, 1984.

Steam Rolled/Flaked Grains:

eTTSD, % Starch = 78+(DSA, % Starch/1.5*0.314)

Note DSA as determined by Blasel et al., 2006 is divided by 1.5 to approximate starch hydrolysis in vivo starch digestibility relationships of Yu et al., 1998.

Summative Energy Calculations: All Feed Grains:

TDN, % DM = (eCP + eStarch + eNon-starch NFC + eFat + eNDF) -7

Where: eCP = CP, % DM*0.92
eStarch= Starch, % DM*eTTSD,% Starch
eNon-starch NFC= (NFC, % DM-Starch, % DM)*0.98
eFat= (EE-1)*2.25 *or* (3.2)*2.25
eNDF= (NDF-NDFCP)*0.8

Alternative Energy Calculations (ME, NEL_{3x}, NEG, NEM: mcals/lb) from TDN as per Nutrient Requirements of Dairy Cattle, 2001

Relative Grain Quality (RGQ)

$RGQ = (0.223*eTTSD^2) + (- 34.42*eTTSD) + 1421$

Table 1. Capstone literature used to establish relationships between grain particle size, grain type, prolamin content and total tract starch digestibility for the Wisconsin Feed Grain Evaluation System. [1,2]

Author(s)	Citation	Grain Type	Processing	Moisture	MPS,mm	TTSD	Trial MPS Slope	Trial TTSD Intercept
Ekinci and Broderick	1997 J. Dairy Sci. 80:3298–3307	HMC	Rolled	32.0	4.33	94.15	-1.77	101.60
		HMC	Ground	32.0	1.66	98.75		
Knowlton et al.	1998 J. Dairy Sci. 81:1972–1984	HMC	Ground	30.0	0.489	98.2	-1.92	99.14
		HMC	Rolled	30.0	1.789	95.7		
Reis et al.	2001 J. Dairy Sci. 84:429–441	HMC	Ground	24.7	2.22	92.4	-5.56	104.90
		HMC	Rolled	24.7	3.14	87.2		
San Emeterio et al.	2000 J. Dairy Sci. 83:2839–2848	HMC	Rolled	30.0	4.43	85.5	-2.03	93.24
		HMC	Ground	30.0	1.32	90.2		
		HMC	Rolled	30.9	3.78	84.1		
		HMC	Ground	30.9	1.02	91.8		
				Moisture	MPS, mm	TTSD	MPS Slope	Intercept
			Mean	29.5	2.42	91.8	-2.82	99.72
			SD	2.66	1.41	5.09	1.83	4.92
			SE	0.16	0.12	0.23	0.34	0.55
Callison et al[3]	2001 J. Dairy Sci. 84:1458–1467	Dry	Fine Grind	15	1.20	98.0	-1.73	98.79
		Dry	Medium Grind	15	2.60	92.2		
		Dry	Coarse Grind	15	4.80	91.3		
Knowlton et al.	1998 J. Dairy Sci. 81:1972–1984	Dry	Ground	15	0.62	88.9	-11.29	95.87
		Dry	Rolled	15	1.73	76.4		
Dhiman et al.	2002 J. Dairy Sci. 85:217–226	Dry	Fine Grind	15	1.13	96.1	-4.81	101.50
		Dry	Coarse Grind	15	1.65	93.6		
Knowlton et al.	1996 J. Dairy Sci. 79:5574€4	Dry	Ground	15	0.83	92.2	-2.71	94.43
		Dry	Cracked	15	3.27	85.6		
		Dry	Ground	9.5	1.25	87.3		
Remond et al.	2004 J. Dairy Sci. 87:1389–1399	Dry	Ground	15	0.70	91.4	-5.25	97.50
		Dry	Ground	15	1.80	86.0		
		Dry	Ground	15	3.70	69.5		
		Dry	Ground	15	0.60	97.3		
		Dry	Rolled	15	3.50	89.2		
San Emeterio et al.	2000 J. Dairy Sci. 83:2839–2848	Dry	Ground	11.1	3.28	80.4	-3.55	92.03
		Dry	Ground	11.1	1.11	88.1		
Yu et al.	1998 J. Dairy Sci. 81:777–783	Dry	Rolled	15	1.18	95.8	-6.61	103.60
		Dry	Rolled	15	2.45	87.4		
				Moisture	MPS, mm	TTSD	MPS Slope	Intercept
			Mean	14	2.0	88.9	-5.14	97.67
			SD	2	1.23	7.2	3.47	3.99
			SE	0.07	0.06	0.14	0.27	0.29
		Grain Type	Processing Method	Prolamin, % Starch	MPS, mm	TTSD	Prolamin Slope	Intercept
Lopes et al.	2009 J. Dairy Sci. (Submitted)	Dry, Dent	Rolled	10.8	1.792	89.6	-0.86	98.9
		Dry, fl2/fl2	Rolled	4.5	1.399	95.1		
		Dry, o2/o2	Rolled	2.6	1.456	96.6		
				Prolamin, % Starch	MPS, mm	TTSD	Prolamin Slope	Intercept
			Mean	5.97	1.5	94	-0.86	98.9

[1] HMC=high moisture corn, MPS=mean particle size, SD=standard deviation, SE=standard error, TTSD=total tract starch digestibility.

[2] Trial Criteria 1) > 80 % of starch from grain, 2) MPS reported, 3)direct comparsion grain type, 4) in vivo TTSD measured.

[3] Non structural carbohydrate digestibility was used as a surrogate for TTSD.

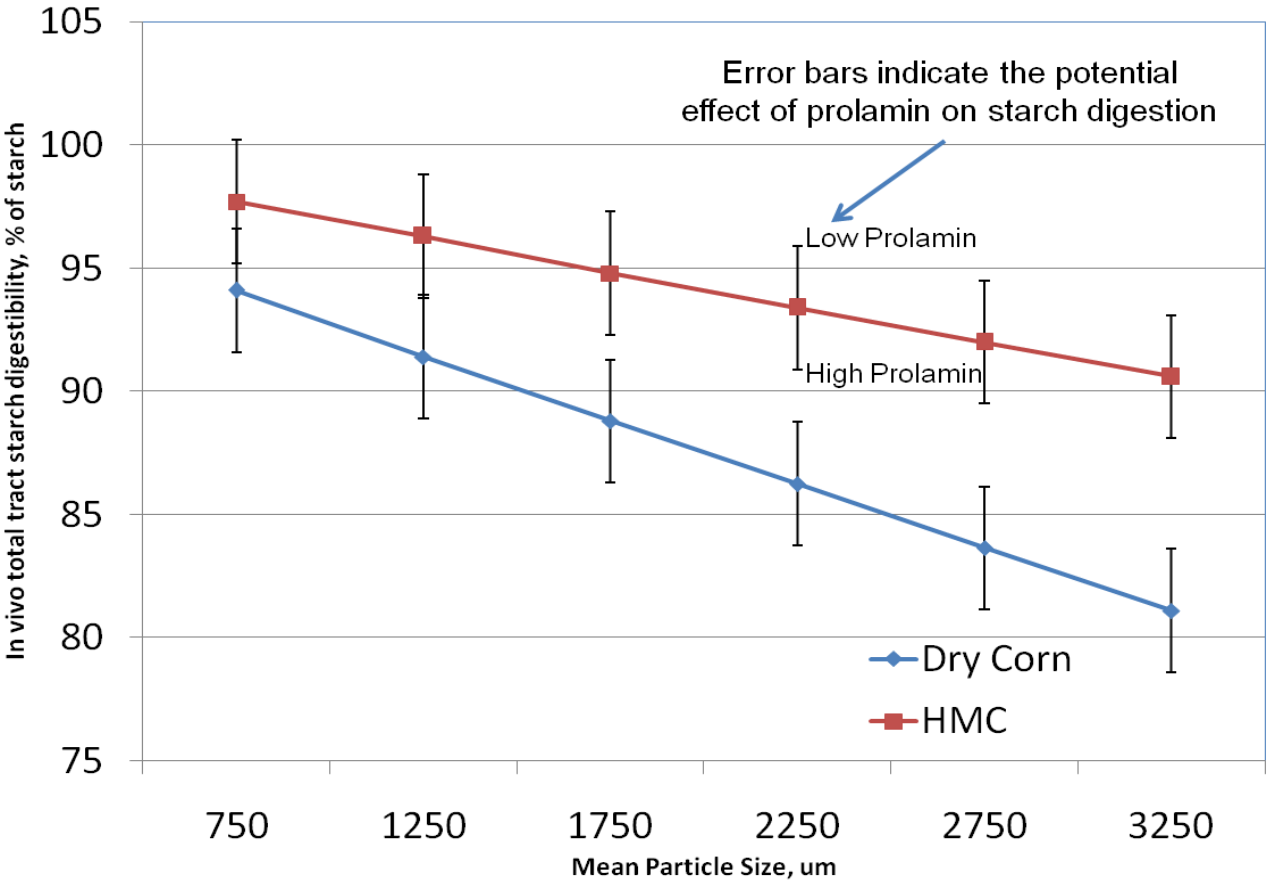

Figure 1. Graphic representation of equations used to estimate in vivo total tract starch digestibility in the UW-Feed Grain Evaluation System.

SOIL and FORAGE ANALYSIS LABORATORY

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UW-Feed Grain Evaluation System

Comments
Example High Moisture Grain

Grain Type	
Dry or HM Corn	x
Small Grain	
Sorghum Milo	
Steam Flaked Grain	

Lab Number 1 *Sample Description*

Item	*Abbrev*	*Unit*	*Result*	*Method* [1]
Dry Matter	*DM*	*% as fed*	70.0	*WC*
Moisture		*% as fed*	30.0	*C*
Protein Fractions				
Crude Protein	*CP*	*% of DM*	9.1	*WC*
Prolamin Protein		*% of DM*	2.3	*WC*
Prolamin Protein		*% of Starch*	3.3	*WC*
Fiber Fractions				
Neutral Detergent Fiber	*aNDF*	*% of DM*	8.4	*WC*
Starch				
Starch		*% of DM*	68.9	*WC*
Mean Particle Size	*MPS*	*microns*	2000	*WC*
Processing Classification			Med-Coarse Grind	
Relative Grain Quality	*RGQ*		174	*C*
Carbohydrates and Fats				
Non Fiber Carbohydrate	*NFC*	*% of DM*	76.3	*C*
Nonstarch NFC		*% of DM*	7.4	*C*
Fat		*% of DM*	4.2	*WC*
Energy Calculations:				
Total Digestible Nutrients, 1X	*TDN*	*% of DM*	89.9	*C*
Net Energy Lactation, 3X	*NE_L*	*Mcals/lb*	0.91	*C*
Net Energy Maintenance	*NE_M*	*Mcals/lb*	0.98	*C*
Net Energy Gain	*NE_G*	*Mcals/lb*	0.67	*C*
Metabolizable Energy, 3X	*ME*	*Mcals/lb*	1.42	*C*

Macro Minerals, % of DM			*Micro Minerals, % of DM*			
Phosphorus	*P*	*wc*	*Iron*	*Fe*		*wc*
Calcium	*Ca*	*wc*	*Manganese*	*Mn*		*wc*
Potassium	*K*	*wc*	*Zinc*	*Zn*		*wc*
Magnesium	*Mg*	*wc*	*Copper*	*Cu*		*wc*
Sodium	*Na*	*wc*				
Chloride	*Cl*	*wc*	*Ash*		2.0	*wc*
Sulfur	*S*	*wc*				

[1] *WC = wet chemistry* *NR = not requested* *C = calculated*
NIR = near infrared spectroscopy *NA = not available*

Figure 2. An example report for the UW-Feed Grain Evaluation System.

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