Straw particle size in calf starters: Effects on Rumen Fermentation and Rumen Development

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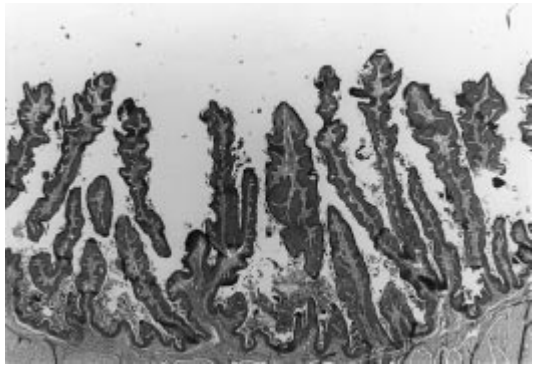
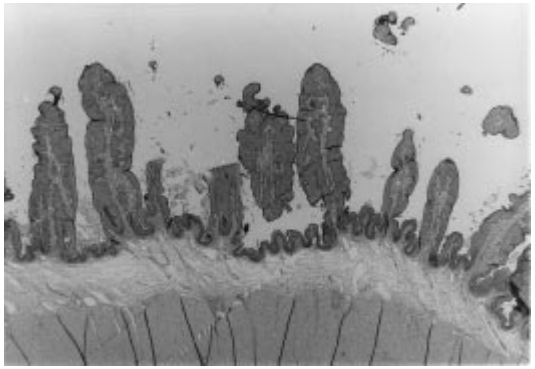
Rumen development

- Starter is the most important feed for inducing rumen development:
  - Rumen papillae growth is stimulated by the products of rumen fermentation rather than by feed coarseness (Flatt et al., 1958).
  - Propionate and butyrate are the most important VFA for papillae growth (Tamate et al., 1962).
- Lack of adequate particle size of starter results in abnormal growth of rumen papillae and lower rumen pH (Greenwood et al., 1997).

Particle size and diet abrasion

- Cross section from ventral cranial sac





Fine **Intermediate** **Coarse**

Greenwood et al., 1997.

Objectives

- Evaluate if particle size of straw fed in calf starter would affect
  - Rumen pH
  - Rumen fermentation
  - Development of the digestive system
- Observe the kinetics of rumen fermentation at an early age.

Trials and calves

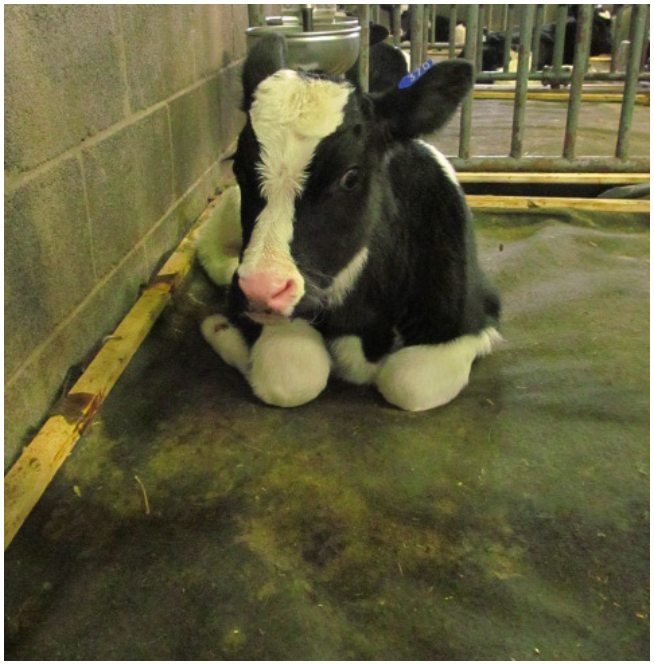
	Diet					*P*-value
	Pelleted	Short	Medium	Long	SE	
Calves, n						
Trial 1	4	4	4	5	-	-
Trial 2	7	6	6	6	-	-
BW at birth, kg	43.5	43.4	44.5	43.9	1.2	0.93
BW at slaughter, kg	64.7	65.2	63.4	67.2	2.5	0.72

- Milk replacer 20/20 was fed to 12% of birth BW
- Starter intake was controlled, orts were fed through the cannula in fistulated calves
- Rumen contents were sampled at -8, -4, 0, 2, 4, 8, and 12 h after starter feeding, weekly after starter was available
- Calves were slaughter after 6 wk of grain feeding

12 cannulated calves

Ingredient composition of diets

% DM	Pelleted	[1]Sup. Pellet
Ground Corn	42.57	44.79
Wheat midds	25.00	26.32
Soybean meal, 48% CP	20.94	22.05
[2]Wheat straw	5.00	-
Cane molasses	3.00	3.15
Calcium carbonate	1.24	1.30
Premix	0.75	0.79
Salt	0.75	0.80
Decoquinate, 6 %	0.50	0.53
Monocalcium phosphate	0.26	0.28



[1] For short, medium and long diets

[2]Straw contained: 3.9 CP, 53.7 ADF, 78.3 NDF, and 8.28 lignin (% DM).

Nutrient composition of diets

Chemical composition	Pelleted	[1]Sup. Pellet	Straw
DM	88.04	86.44	96.40
% DM			
CP	17.69	19.98	3.90
Starch	37.06	39.50	-
Fat	3.79	3.73	-
ADF	8.39	6.57	53.70
NDF	15.22	12.43	78.30
Ash	6.13	6.17	6.30
Ca	0.90	1.06	0.26
P	0.55	0.57	0.11

[1] For short, medium and long diets

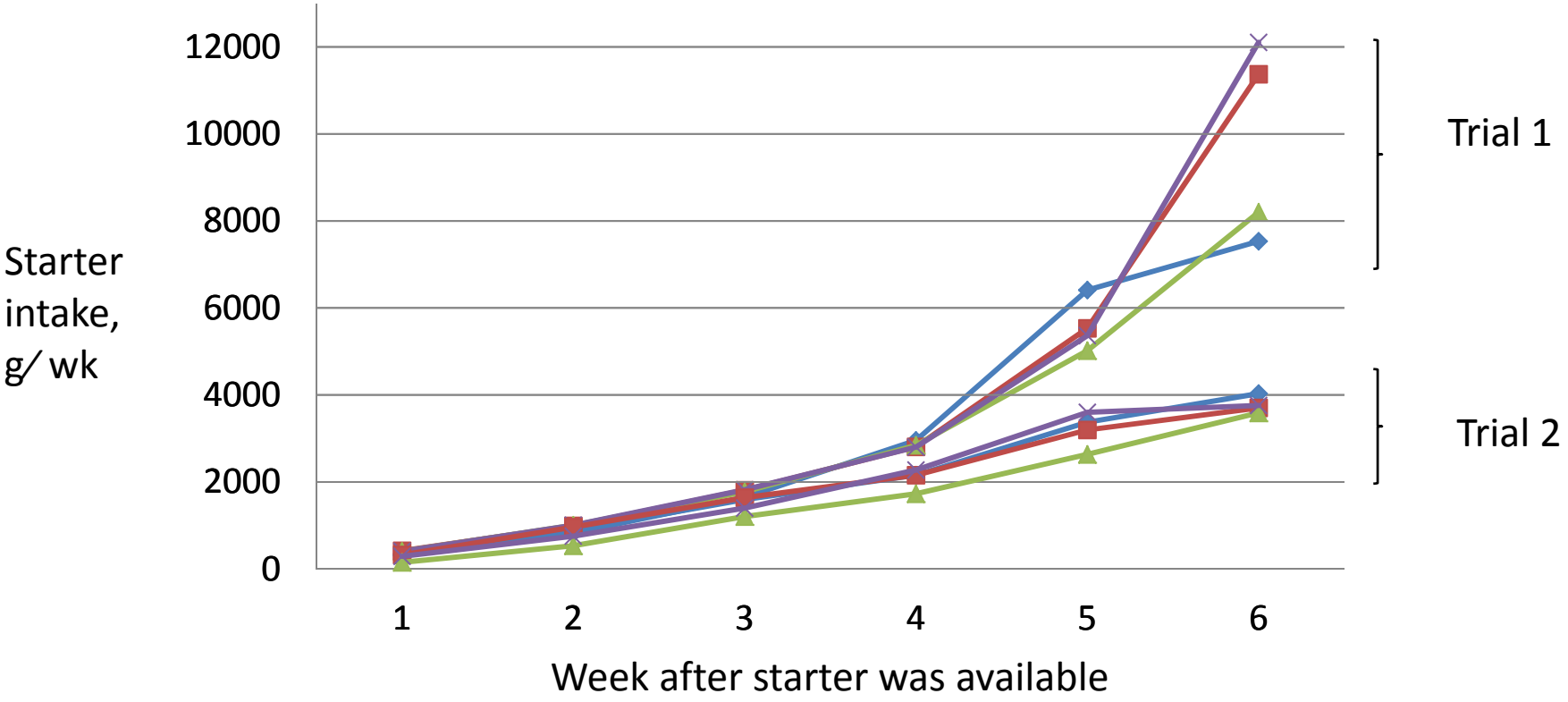
Particle size of diets

Straw	Diet			
	Pelleted	Short	Medium	Long
[1]X_{gm} retained, mm	0.82	3.04	7.10	12.7

Starter	Pelleted	Sup. Pellet
[1]X_{gm} retained, mm	1.19	1.19
[2]S_{gm} retained, mm	1.17	1.16
[1]X_{gm} [3]total, mm	0.61	0.60
[2]S_{gm} [3]total, mm	1.53	1.54

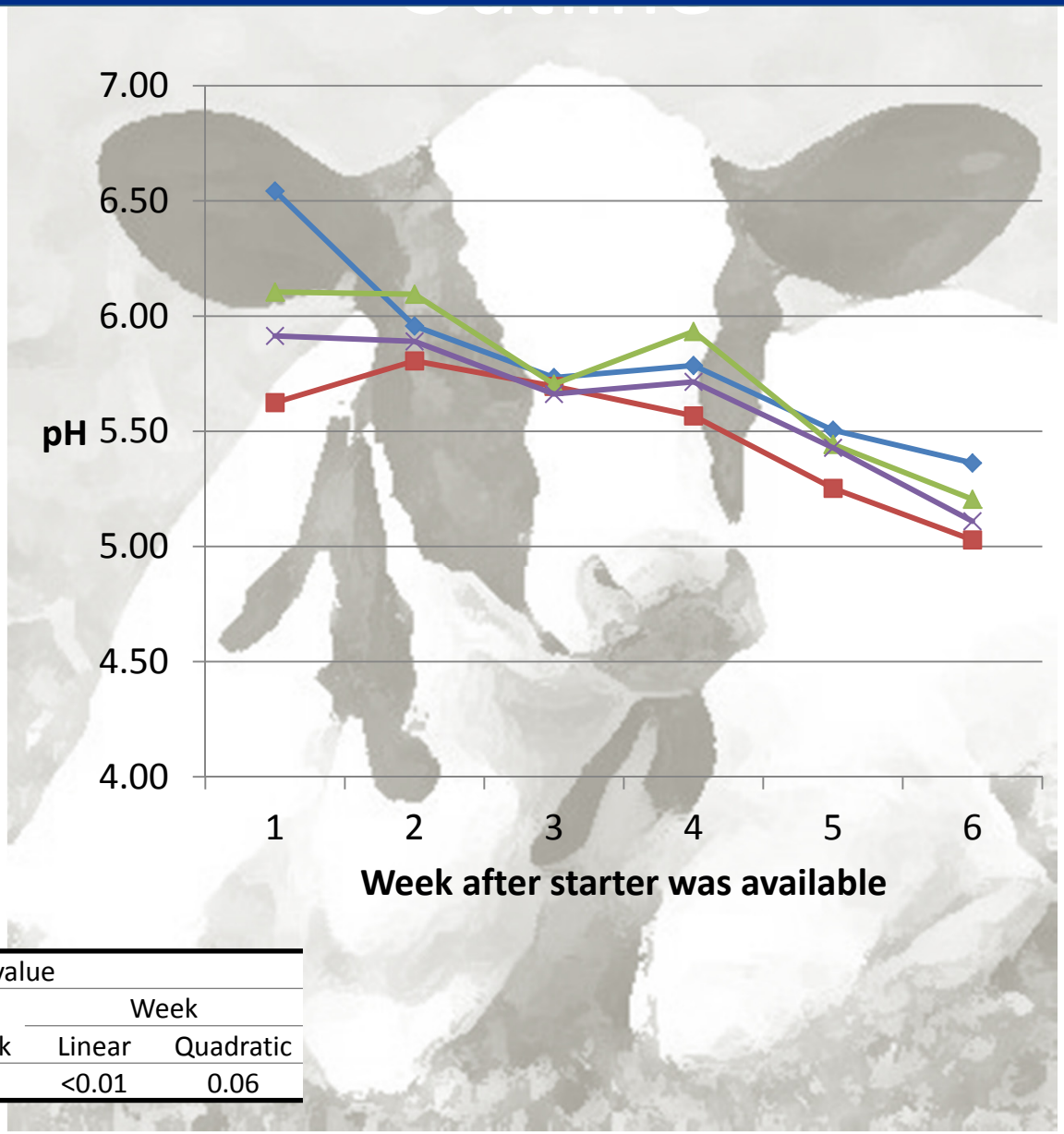
[1]Geometric mean particle length (X_{gm}) as calculated by ASABE (2007)
[2]Standard deviation of particle length (S_{gm}) as calculated by ASABE (2007)
[3]Using data from all particle fractions and a mean length of 0.106 mm for particles that passed through the bottom screen

Starter intake



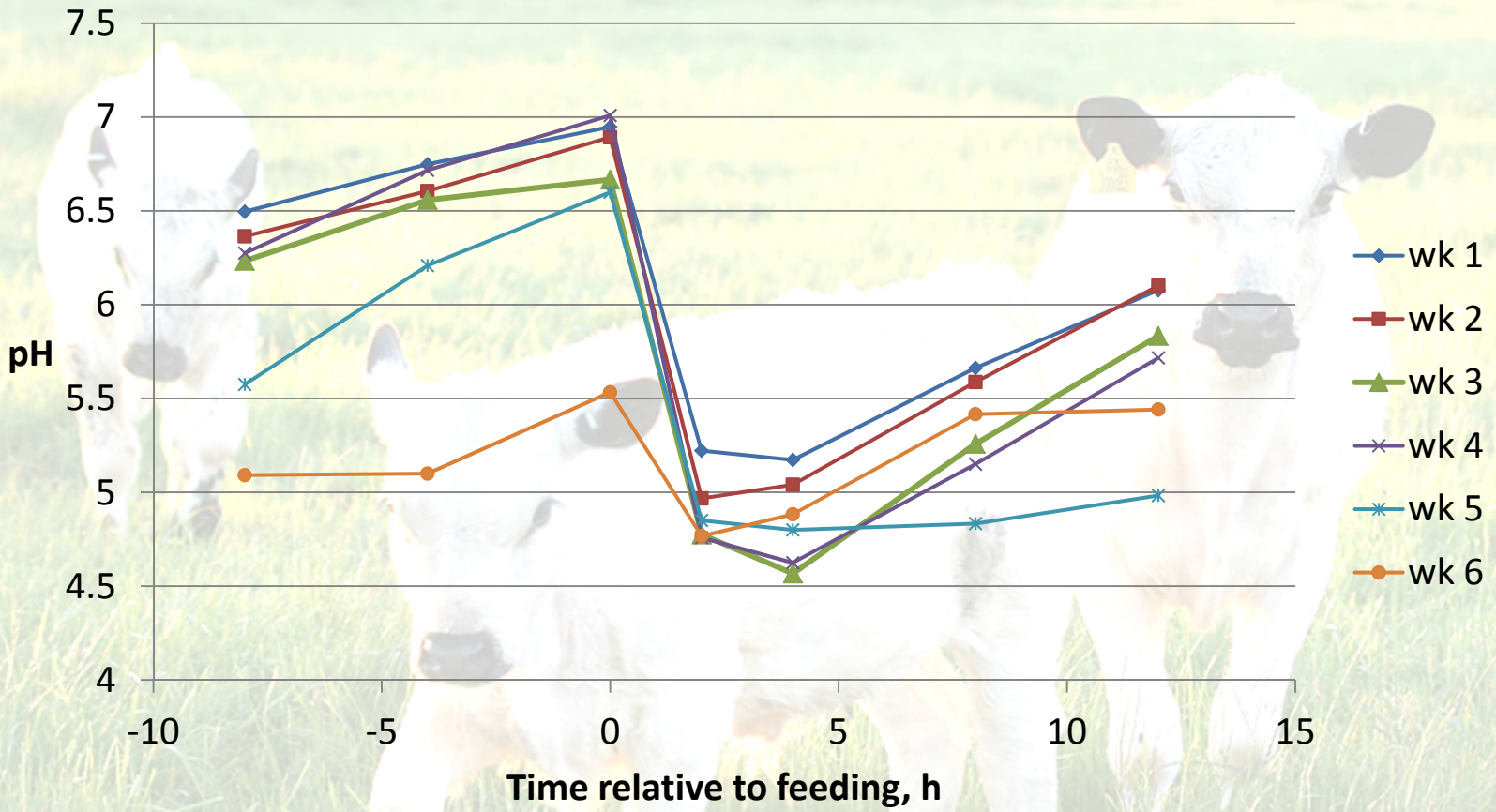
		P-value		
			Week	
Trial	Diet	Diet*Week	Linear	Quadratic
1	0.44	0.03	<0.01	<0.01
2	0.69	0.77	<0.01	0.04

Rumen pH



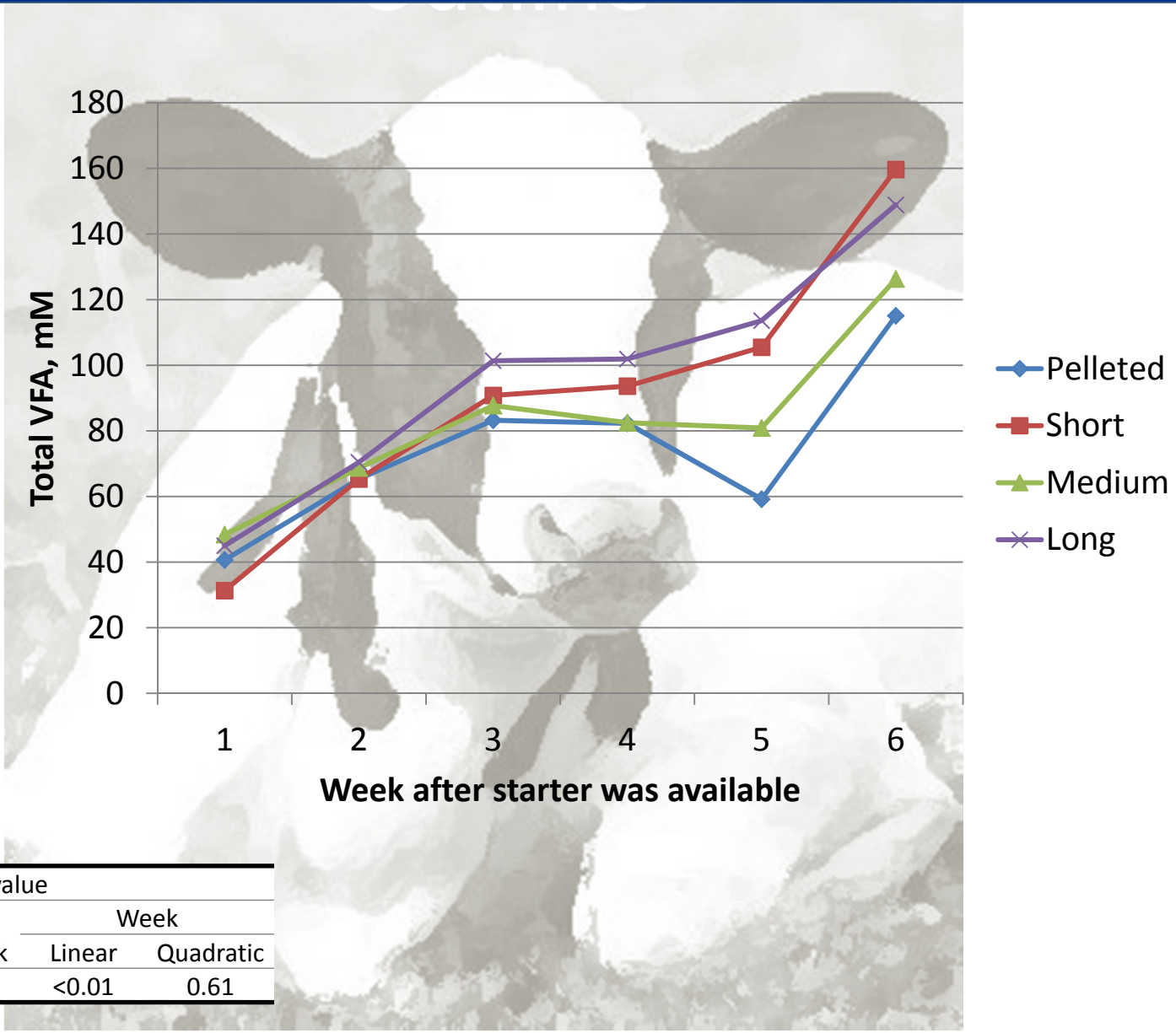
P-value			
		Week	
Diet	Diet*Week	Linear	Quadratic
0.04	0.08	<0.01	0.06

Rumen pH



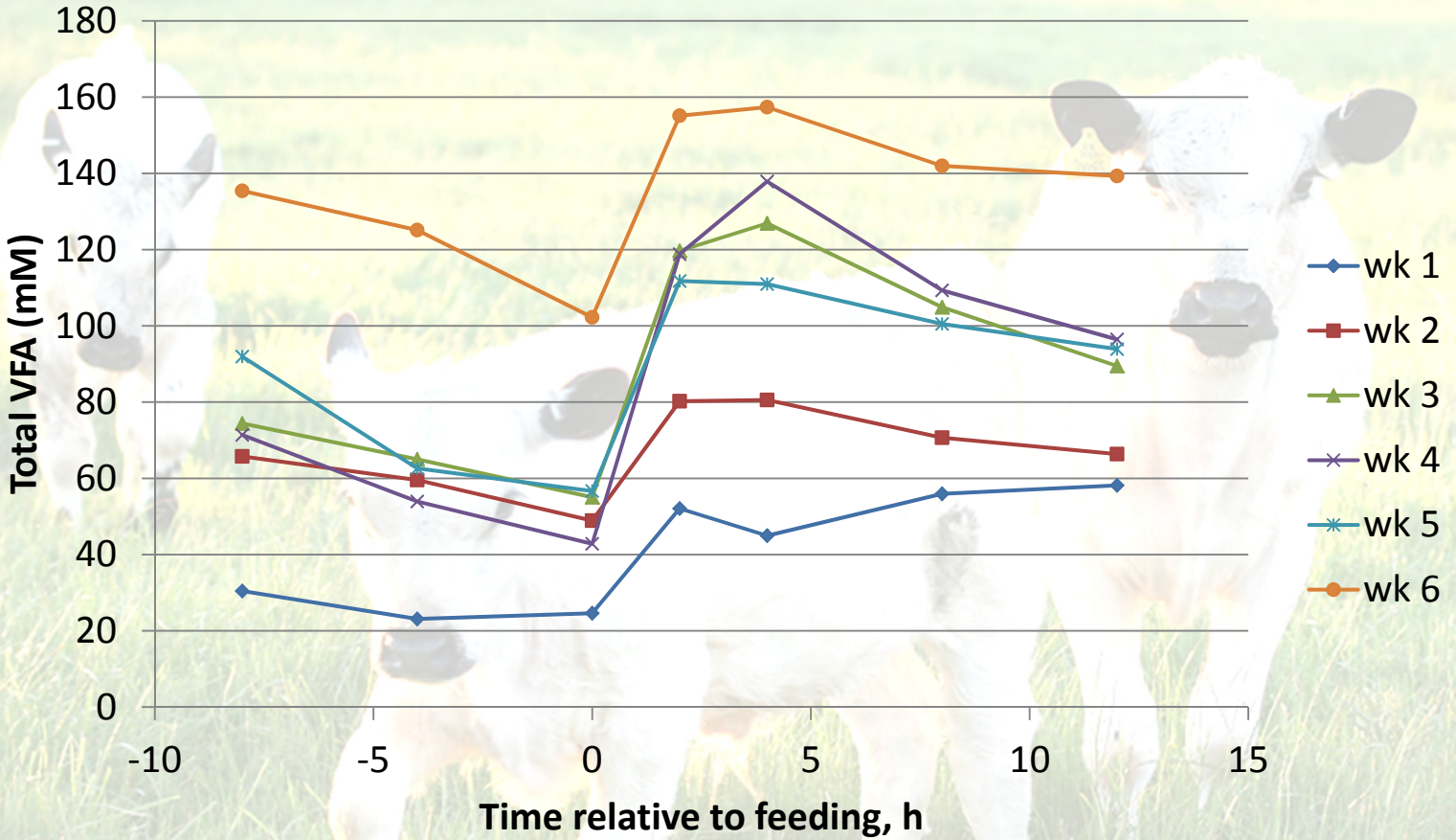
P-value				
		Week		
Time	Time*Week	Linear	Quadratic	Cubic
<0.01	<0.01	<0.01	0.06	0.25

Rumen Total VFA



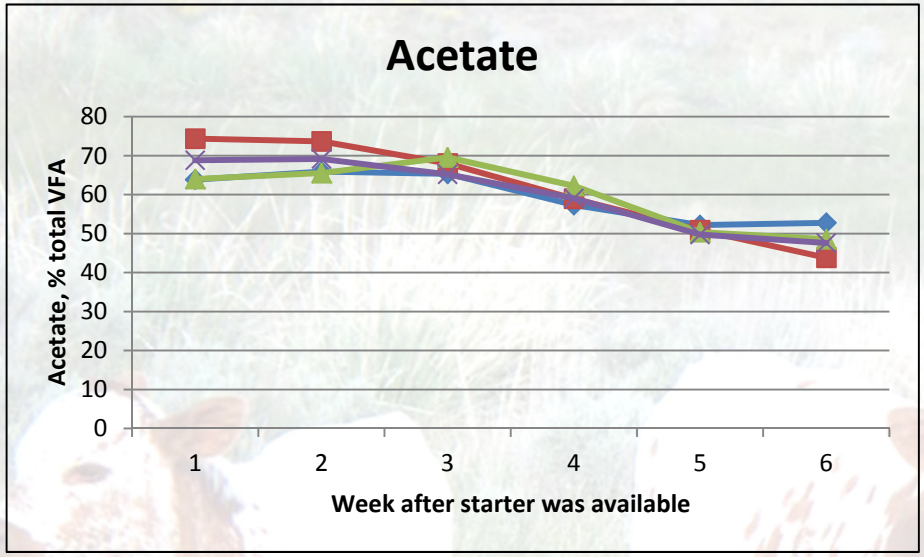
P-value			
		Week	
Diet	Diet*Week	Linear	Quadratic
0.54	<0.01	<0.01	0.61

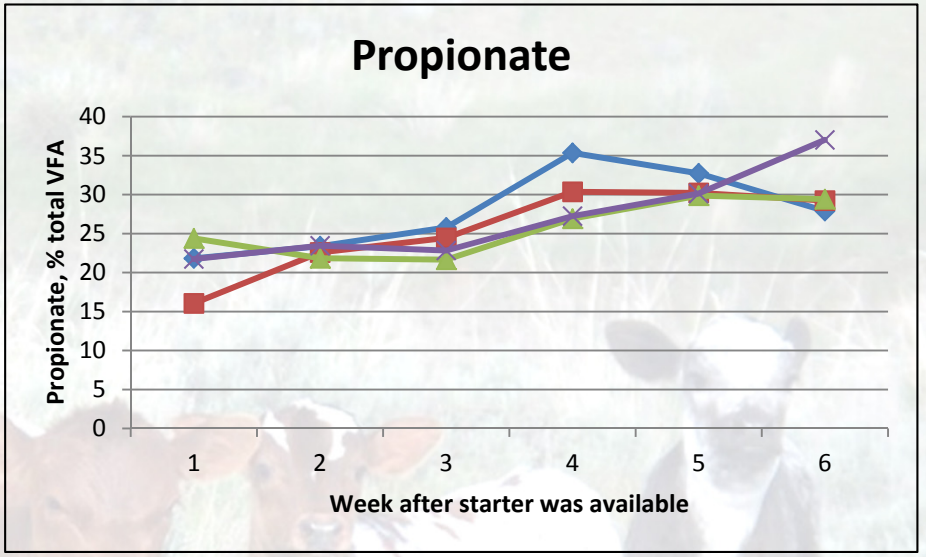
Rumen Total VFA

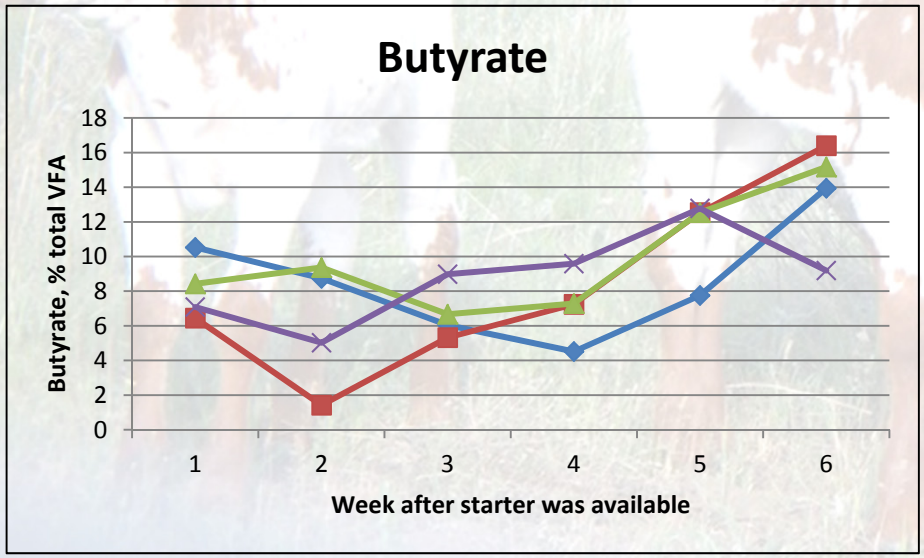


P-value				
		Week		
Time	Time*Week	Linear	Quadratic	Cubic
<0.01	<0.01	<0.01	0.73	<0.01

Rumen individual VFA







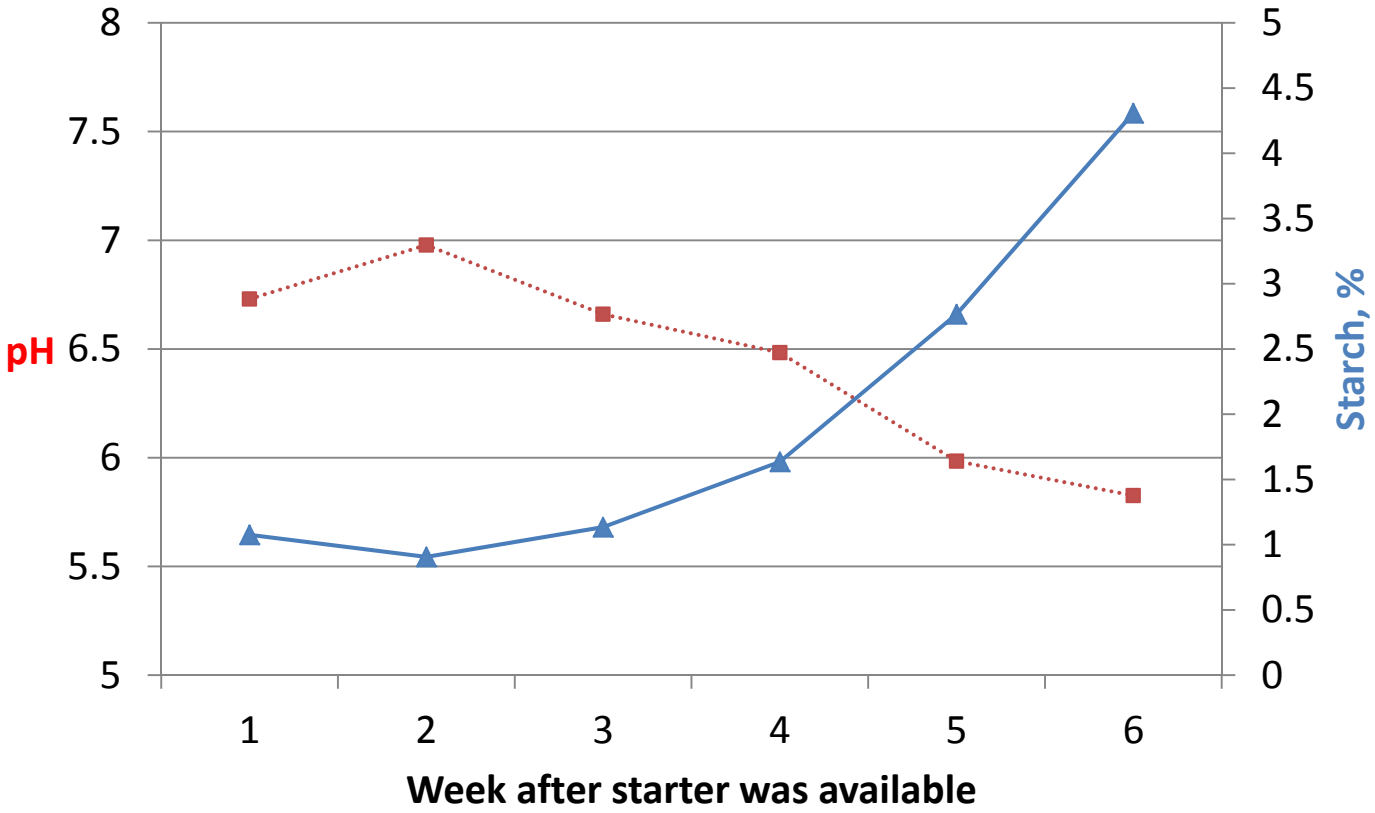
	P-value			
			Week	
	Diet	Diet*Week	Linear	Quadratic
Acetate	0.80	0.08	<0.01	<0.01
Propionate	0.95	0.12	<0.01	<0.01
Butyrate	0.64	<0.01	<0.01	0.46

Fecal particle size

	Diet					P-value			
								Week	
	Pelleted	Short	Medium	Long	SE	Diet	Diet*Week	Linear	Quadratic
[1]X_{gm}, retained	0.66	0.69	0.68	0.64	0.03	0.40	0.55	0.35	0.01
[2]S_{gm}, retained	1.11	1.14	1.14	1.12	0.01	0.04	0.80	0.13	0.04
[3]X_{gm}, total	0.36	0.37	0.37	0.35	0.01	0.45	0.12	0.01	<0.01
[4]S_{gm}, total	1.33	1.35	1.35	1.32	0.01	0.23	0.35	0.20	<0.01
Retain, %DM									
3.35-mm sieve	3.00	5.62	6.62	5.02	0.70	0.01	0.89	0.28	0.41
1.18-mm sieve	6.29	6.92	5.25	4.37	0.64	0.04	0.33	0.50	<0.01
1.0-mm sieve	4.28	4.10	4.11	3.74	0.36	0.70	0.18	0.01	0.01
0.85-mm sieve	3.11	2.98	3.05	2.45	0.26	0.23	0.95	0.03	0.10
0.6-mm sieve	14.23	12.82	12.47	12.14	1.09	0.53	0.13	<0.01	0.07
0.425-mm sieve	21.07	19.40	19.13	20.21	0.74	0.26	0.97	0.01	0.52
0.15-mm sieve	47.98	48.16	49.37	52.07	2.79	0.66	0.63	0.03	0.01
[5]Solubles, % of DM	70.20	72.72	71.50	71.07	2.22	0.88	0.50	<0.01	0.23

[1]Geometric mean particle length (X_{gm}) as calculated by ASABE (2007)
[2]Standard deviation of particle length (S_{gm}) as calculated by ASABE (2007)
[3]Geometric mean particle length (X_{gm}) as calculated by ASABE (2007) including particles that passed through the bottom screen.
[4]Standard deviation of particle length (S_{gm}) as calculated by ASABE (2007)
[5]Proportion of particles that passed through the bottom screen.

Fecal pH and starch



	P-value			
			Week	
	Diet	Diet*Week	Linear	Quadratic
pH	0.13	0.41	<0.01	<0.01
Starch	0.41	0.74	<0.01	<0.01

Rumen development

	Diet					P-value	
	Pelleted	Short	Medium	Long	SE	Diet	Trial
Xylose, mg/dL	33.8	30.5	30.5	35.0	1.4	0.02	<0.01
Slaughter data							
Carcass, kg	47.9	47.2	46.4	49.4	1.6	0.57	0.08
Reticulorumen, g	721	766	688	742	45	0.65	<0.01
Omasum, g	245	217	206	200	17	0.27	<0.01
Abomasum, g	265	292	264	265	11	0.25	<0.01
Liver, g	1135	1146	1083	1107	43	0.73	<0.01
Spleen, g	167	177	159	170	10	0.63	0.01
Organ proportion of BW at harvest							
Reticulorumen, %	1.10	1.17	1.06	1.09	0.05	0.55	<0.01
Omasum, %	0.38	0.33	0.32	0.29	0.02	0.06	<0.01
Abomasum, %	0.41	0.45	0.42	0.39	0.02	0.20	0.03
Liver, %	1.76	1.75	1.71	1.64	0.05	0.29	<0.01
Spleen, %	0.26	0.27	0.25	0.25	0.01	0.50	0.19
Papillae length, mm	0.84	0.79	0.77	0.80	0.06	0.85	0.04
Papillae width, mm	0.49	0.49	0.48	0.46	0.02	0.57	<0.01
RWT, mm	0.79	0.79	0.80	0.76	0.07	0.97	<0.01

Conclusions

- Increasing particle size of starter by changing the particle size of straw at a 5% inclusion rate resulted in:
  - Minimal changes in rumen fermentation
  - No effect on rumen parameters
  - Decreased omasum weight as particle size increased
  - No change on fecal pH and starch content.

Questions?