Nutritional Regulation of Gut Function: Pre-weaning



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- I. Calf Management TrendsII. Pre-weaning
 - Colostrum feeding
 - Colostrum transition
 - Milk feeding in the first weeks





Early Life Nutrition

 Dietary regimes in early life influence lifetime productivity

Ilb of pre-weaning ADG = 1,540 lbs of milk in first lactation

(Soberon et al., 2012)





Early Life Nutrition: Future Milk

Study	Milk yield, kg
Foldager and Krohn, 1991	1,405 ^s
Bar-Peled et al., 1998	453 ^t
Foldager et al., 1997	519 ^t
Ballard et al., 2005 (@ 200 DIM)	700 ^s
Shamay et al., 2005 (post-weaning protein)	981 ^s
Davis-Rincker et al., 2011	416 ^{ns}
Drackley et al., 2007	835°
Raith-Knight et al., 2009	71 ^{8ns}
Terre et al., 2009	624 ^{ns}
Morrison et al., 2009 (no diff. calf growth)	O ^{ns}
Moallem et al., 2010 (post-weaning protein)	732 ^s
Soberon et al., 2012	 552 ^s

"Nutritional Programming"

"...early adaptation to a stress or stimuli that permanently changes the physiology and metabolism of the organism and continues to be expressed even in the absence of the stimulus/stress that initiated them..."

(Patel and Srinivansan, 2002)



(Adapted from Conrad's Waddington epigenetic landscape)

Gut Health and Dairy Calves

10% mortality and over 50% of morbidity is related to calf diarrhea (NAHMS, 2007)

19% of calves fail passive transfer of Ig and 24% of calves have calf diarrhea in the first month (NAHMS., 2007)



 Antibiotic use pre-weaning has been associated with decreased lifetime milk production (Soberon et al., 2012)

Knowledge Gaps



Colostrum Feeding Method Bottle Tube



(Sharifi et al., 2009)

Colostrum Feeding Method

lgG 25 Mean lgG Conc. (mg/ml) 20 15 ---Bottle 10 ---Tube 5 0

0

1000 1500 2000 2500 500 **Time Relative to Colostrum** Feeding (minutes)

Acetaminophen



(Desiardins-Morrissette et al., 2018)



(Fischer et al., 2018)

Delayed Colostrum Feeding



 Delaying the first colostrum meal may delay the colonization of beneficial bacteria to the calf intestine

(Fischer et al., 2018)

Heat Treatment of Colostrum



NC = No Colostrum FC = Fresh Colostrum HC = Heated Colostrum

 Heat-treated colostrum increases *Bifidobacterium* and reduced the colonization of *E. coli* in the small intestine (Malmuthuge et al., 2015)

Heat Treatment of Colostrum



Bovine Colostrum Oligosaccharide (Fischer et al., 2018)

 Heat-treatment may cleave prebiotic oligosaccharides from colostral proteins and lipids

Oligosaccharides – Transition



 Bovine colostrum oligosaccharides (bCOs) produced in higher concentrations immediately after parturition (Fischer et al., 2018)



			Mature				
	Unit	1	2	3	4 5	5	Milk
Dry Matter	%	24.5	19.0	16.0	15.5	15.3	12.2
Fat	%	6.4	5.6	4.6	5.0	5.0	3.9
Protein	%	13.3	8.5	6.2	5.4	4.8	3.2
Essential Amino Acids	mM	390	230	190	140	115	ND
Lactoferrin	g/L	1.84	0.86	0.46	0.36	ND	ND
Insulin	μg/L	65	35	16	8	7	1
Growth Hormone	μg/L	1.5	0.5	ND	ND	ND	ND
Insulin-like growth factor I	μg/L	310	195	105	62	49	ND

Improved health status in calves fed transition milk

(Conneely et al., 2014)

- All calves fed one meal of colostrum followed by:
 - Milk
 - 50% milk/ 50% colostrum (Transition)
 - Colostrum











Colostrum



(Pletts et al., 2018)

Passive Transfer

- Trancytosis of immunoglobulins (Jochims et al., 1997)
- Receptor mediated and highly regulated
 - Trancytosis (to blood)
 - Recycling (back to lumen)
 - Metabolism (endosome)
- Regulation of these pathways in calves is unclear



Normal Pre-Weaning Milk Intake





(Jasper and Weary, 2002)

(de Passille et al., 2016)

Feeding Large Meals

 Calves typically nurse 6-12 times per day in the first weeks of life (Jensen, 2004)



- Larger meals fed less frequently increase the risk of:
 - Abomasal inflammation & lesions
 - Milk overflow into the rumen
 - Ruminal acidosis, decreased passage rate and digestion

(Berends et al., 2012; 2015)

Inflamed Abomasum

Abomasal Capacity



- Young calves fed 2 litres of milk per meal (3 x)
- Offered ad libitum meal of milk with barium sulfate
- Most calves drank more than 5 litres with no evidence or ruminal overflow

(Ellingsen et al., 2016)

Larger Meal Size and Insulin Sensitivity

- Compared calves fed elevated (8L/d) vs low (4L/d) plane of milk 2x per day
 - No evidence of post-prandial hyperglycemia and hyperinsulinemia
 - No difference in glucose tolerance
 - Slower (41% reduction, P = 0.02) abomasal emptying rates during the pre-weaning phase (MacPherson et al., 2016)





Gastric Emptying and Glucose-Insulin Dynamics



Gastric Emptying and Glucose-Insulin Dynamics



Gastric emptying rate will influence glucose appearance in blood

(Stahel et al., <u>2016</u>)

Take Home Messages

- There are still some basic concepts in calf biology and nutrition that we do not understand
- No difference between tube vs. bottle feeding colostrum for passive transfer
- Delaying colostrum by six hours can impact passive transfer and gut microbiology
- Pasteurizing colostrum may help to improve calf gut health if managed properly

Take Home Messages

- An abrupt transition from colostrum to milk can compromise gut development
- Elevated planes of milk can be fed early in life
- Elevated planes of milk can be fed with 2x/day feeding schemes

