Dairy replacement nutrition: What we have learned in the last five years

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Growing Tomorrow's Herd

Key topics

- Retrospective look at calf nutrition
- Purposeful starter grain nutrition
- Evaluating the milk feeding program
- Just a pinch of additives
- Automated calf feeding tips
- Transition calf program

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Striking similarities between the transition cow and the nursery calf

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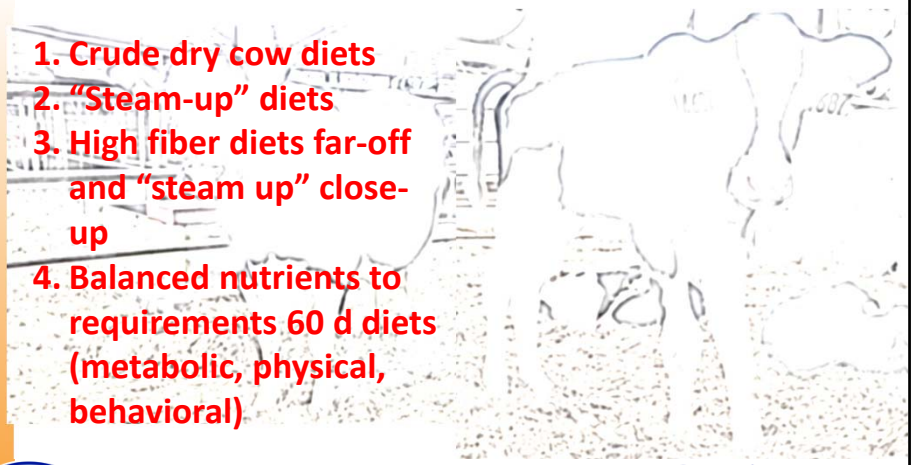
Striking similarities between the transition cow and the nursery calf

1. Crude dry cow diets
2. "Steam-up" diets
3. High fiber diets far-off and "steam up" close-up
4. Balanced nutrients to requirements 60 d diets (metabolic, physical, behavioral)



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Striking similarities between the transition cow and the nursery calf

1. Crude dry cow diets
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1. Low milk diets
2. Accelerated feeding
3. Ad libitum whole milk feeding.
4. Balanced nutrients to requirements 60 d diets (metabolic, physical, behavioral)

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Why is calf growth important to dairy producers?

- Calf growth is the expression of health, wellbeing, and adequacy of nutrition and resource management.

Higher ADG indicates greater calf health.

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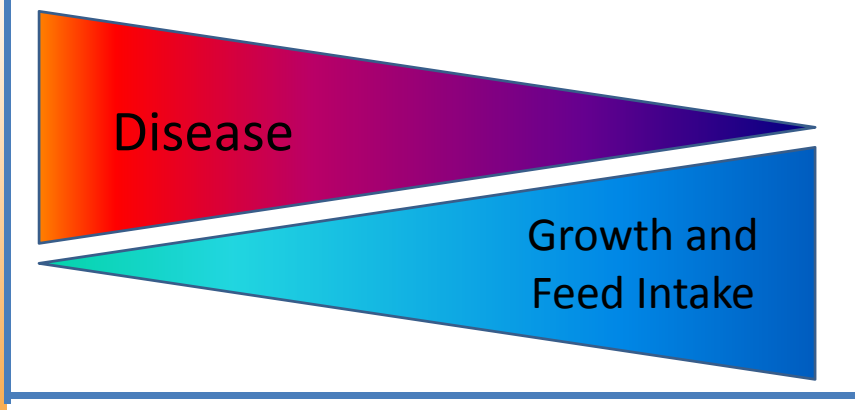
Nutrition, growth, and health are highly interrelated



Adapted from R. W. Johnson, UIUC

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4 key calf nutrition concepts

1. **The first 24 hours have tremendous influence.**
2. **We grow calves from the inside out.**
   - Guts and liver before muscle and skeleton
3. **Calf guts and liver do not appear overnight**
   - Good things come to those who ruminate
4. **Calf nutrient requirements are dynamic but predictable.**
   - Follow key principles of nutrition
   - Goldilocks theory applies to dry cows and calves

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Calves are a part of an energy system where heat is exchanged

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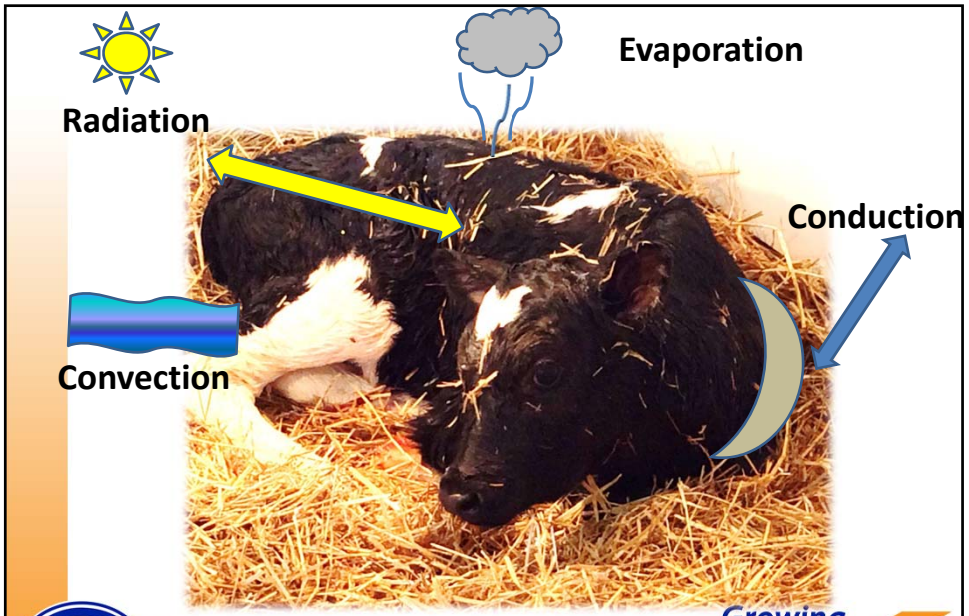

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Calf thermodynamics-Matter is neither created nor destroyed, but does change forms

Nutrient Supply
- Milk
- Starter
- Water

- Maintenance
- Growth
- Environment
- Manure/urine
- Immune function
- Exercise

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Factors impacting calf energetics

	Inefficiencies
Maintenance	Gut damage repair and regrowth
Growth	Slow rate of growth
Environment	Heat and cold stress
Manure/urine	Overfeeding protein
Immune function	Immune challenge = 43 g glucose/hr.
Exercise	Lying vs standing time

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Building and developing the rumen

- Acquisition of anaerobic microbes
- Establishment of rumen fermentation
- Expansion of rumen volume
- Differentiation and growth or rumen papillae
- Development of absorption and metabolic pathways
- Maturation of salivary glands
- Development of rumination behavior

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Why is starter grain important for dairy calves?

- **Develop rumen tissue important for absorption of microbial end-products of fermentation (VFA).**
- **Increased energy-from fermentation of starter grain in the rumen.**
  - Heat of fermentation
- **Increase protein available for growth**
  - From bacterial cells produced in the rumen.

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Why is starter grain important for dairy calves?

- **Increase both microbial mass and diversity (competitive environment for pathogens)**
- **Bacterial fermentation results in production of B-vitamins.**
- **Ensure adequate amount of coccidiostat is being consumed.**

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Why is starter grain important for dairy calves?

- **Stimulate cud chewing and rumination while resting.**
  - Chewing cud is a hallmark of being a ruminant.
- **Increase water intake**
  - Water is the primary component of skeletal muscle
- **Increased colonic health**
  - The result of a healthy colon is increased water absorption and increased consistency of calf manure
- **Provide vitamins and trace minerals needed for growth**
  - Not provided in adequate amounts in whole milk

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Key factors determining starter grain intake

- Amount of milk (fat) fed
- Feeding calf starter with purpose
- Starter grain formulation
- Starter grain quality

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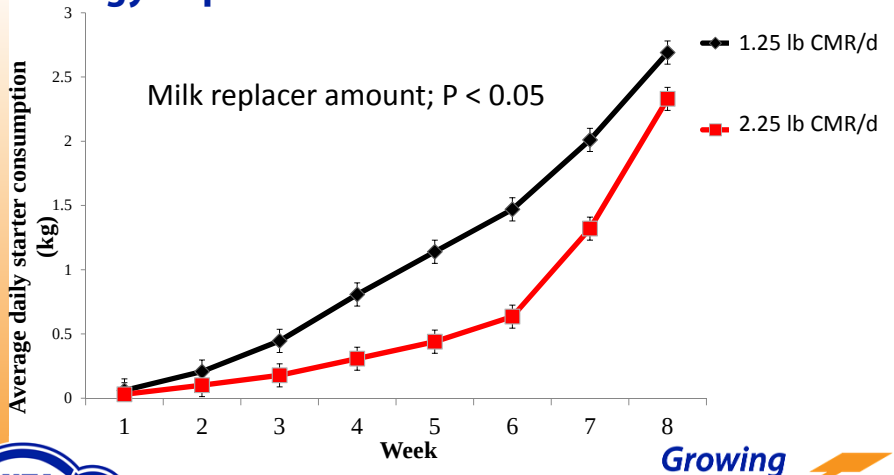
Higher plane of nutrition from milk resulted in lower starter intake even during heightened energy requirements of thermal stress



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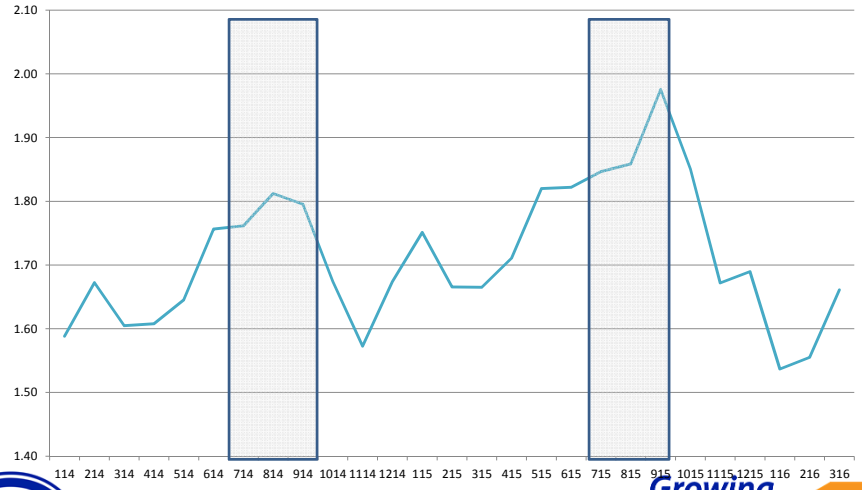
27 month ADG
average = 1.71, lb/d



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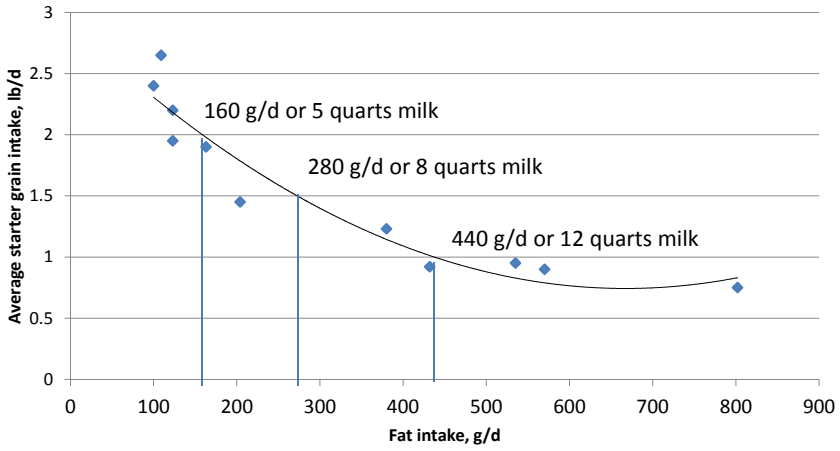
We can feed about 160 g/d milk fat before starter intake averages < 2.0 lb./day



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How to feed starter with purpose

- **Offer 0.25 pounds week 1 to 2**
- **Keep fresh and increase as needed**
  - Do not add fresh grain on top of stale grain.
- **Calves like to eat off of the bottom of the bucket**
- **Maximize intake and minimize shrink loss.**

Optimal intake of calf starter grain

Age, week	Starter intake, pounds/day	Starter intake, pounds/week
1	trace	trace
2	0.25	1.8
3	0.75	5.3
4	1.25	8.8
5	1.75	12.3
6	2.25	16.3
7 (Drop PM milk feeding)	3.5	25.0
8 (No Milk)	5.5	37.6
9	6.0	41.7
Average	2.6	149

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How to build a great starter?

- **Freshness and quality of ingredients**
- **Corn processing**
  - Minimize fines
- **Meet effective fiber requirements**
- **Maximize intake**
- **Low molasses**

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Starter ingredient selection and processing

	Steam Flaked Corn	Rolled Corn	Whole Corn
# Calves	30	30	29
Weight Gain, lb			
Day 0-21	26.3[ab]	**21.7[a]**	**27.4[b]**
Day 0-38	60.3	54.8	56.8
ADG, lb/d	1.59	1.44	1.50
Starter Intake, lb/d (35 d)	2.24[a]	1.84[b]	2.12[a]

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Kibbled Corn

	Kibbled Corn	Steam Flaked Corn	Whole corn
Starch digestibility, %	91.1	84.1	80.9

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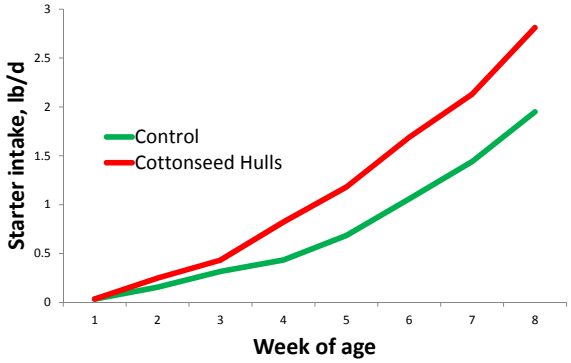
Cottonseed hulls increased starter intake and growth



	Control	Cottonseed hulls	Difference
Total gain, lb	82.6	94.6	+12
Hip height, in	4.7	5.6	+0.9
Starter intake, lb	42.5	65.5	+23

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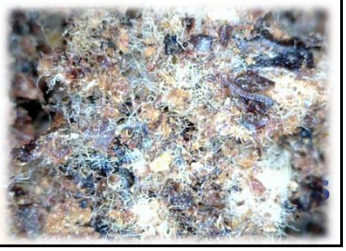
Cotton seed hulls alter rumen function

Item	Control starter	Control + 15% cottonseed hulls	*P*-Value
Starter intake, lb/d	1.67	1.98	0.01
Rumen Papillae			
Width, mm	0.41	0.32	0.01
Density, n/cm2	36.5	48.4	0.14
VFA, mol/100 mol			
Acetate	42.6	43.2	0.76
Propionate	38.6	40.3	0.73
Butyrate	12.0	9.3	0.38

Hill et al., 2009



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BSF Calf Starter Grain

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Cottonseed hulls can hold ~3.0 X their weight in water and have mildly abrasive properties

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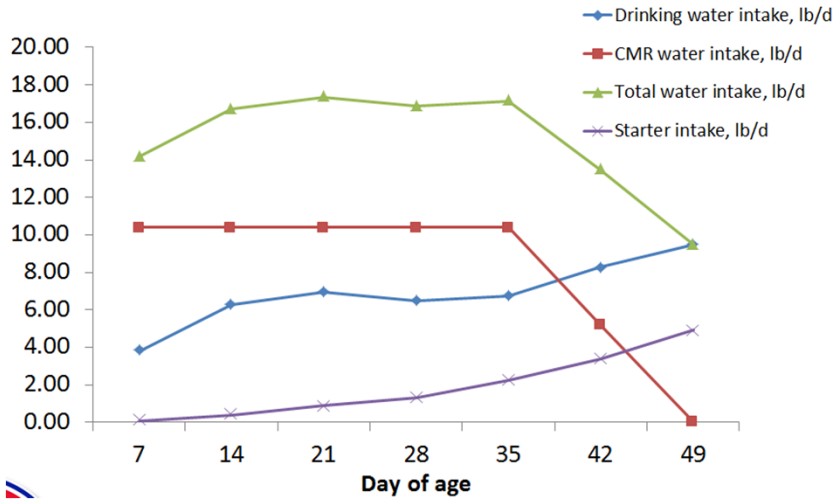
Drinking Water Intake



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Drinking Water

Tips to increase water intake:

- Offer clean, fresh and warm drinking water within 10 minutes of feeding milk to maximize water intake.
- Do not over- or underfeed water.
- Aim for targeted feeding amounts of drinking water.
  - A simple rule of thumb is to multiply the calf's age in weeks by **three** to get the targeted pounds of water intake per day up to weaning.

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Feeding drinking water

Age, week	Suggested drinking water intake, pounds/day	Suggested water intake, gallons/day
1	2	0.25
2	4	0.5
3	6	0.75
4	8	1.0
5	10	1.25
6	12	1.5
7 (Drop PM milk feeding)	20	2.5
8 (No milk)	24	3.0
9	30	3.75

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Selecting a milk feeding plan

- **Key questions**
  - What is the starting calf weight?
  - What is the targeted weaning weight?
  - What is the targeted investment/gain?

ADG (85 lb BBW)	56 d 8 wks	70 d 10 wks
1.2	152	169
1.4	163	183
1.6	175	197
1.8	186	211

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Consequences of solids variation

- **When solids are too high (> 15%)**
  - Slow rate of abomasal emptying rate
  - Water movement into GI tract
- **When solids are too low (< 11%)**
  - Digestive enzymes are diluted below optimal levels

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Milk solids intake expressed as a percentage of calf body weight
Calculated based on 12.5% solids

milk, quarts	calf body weight 75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	165
4	1.5	1.4	1.3	1.2	1.2	1.1	1.0	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.7	0.7	0.7
6	2.2	2.1	1.9	1.8	1.7	1.7	1.6	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.1	1.1	1.1	1.0
8	2.9	2.8	2.6	2.4	2.3	2.2	2.1	2.0	1.9	1.8	1.8	1.7	1.6	1.6	1.5	1.5	1.4	1.3
9	3.3	3.1	2.9	2.8	2.6	2.5	2.4	2.3	2.2	2.1	2.0	1.9	1.8	1.8	1.7	1.7	1.6	1.5
10	3.7	3.4	3.2	3.1	2.9	2.8	2.6	2.5	2.4	2.3	2.2	2.1	2.0	2.0	1.9	1.8	1.8	1.7

Green = Generally accepted safe and comfortable feeding rate under most conditions

Yellow = Some caution should be exercised, feeding rates may be too low or too high based on conditions

Red = Use extreme caution, feeding rates will be too low or excessively high.

Based on milk intake only. Always provide fresh starter grain to calves to allow them to compensate for nutrients not supplied by milk.

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Recommend backing down the amount of milk fed

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Milk Feeding Step-up Program

- **Do not flood calves out, higher risk for health disorders**
  - Scouring during the first 14 days will reduce growth rate and damage intestinal lining, increase risk for increased severity and duration of scours.
  - Increase energy and protein requirements for immune function
  - Oxidative damage.
- **Reduced growth rate due to inefficiencies of immune function and reduced nutrient intake and absorption.**

	Baseline	24 h	48 h	*P*-value
Body weight, lb	87.2	78.7	75.4	<0.05
Plasma volume, L	3.4	ND	2.5	<0.05
Cardiac output, L/min.	8.8	4.5	3.9	<0.05
Urine, mL/h	81	61	12	<0.05
Fecal consistency (0 to 3)	0	3	3	<0.05
Fecal dry matter, %	28	ND	9	<0.05

- **Nutritional scours induction protocol.**
  - Very high plane of nutrition (5 % of BW/d).
  - Sucrose solution (600 mOsm/L).
  - "Calves suckled the milk replacer-sucrose solution readily".

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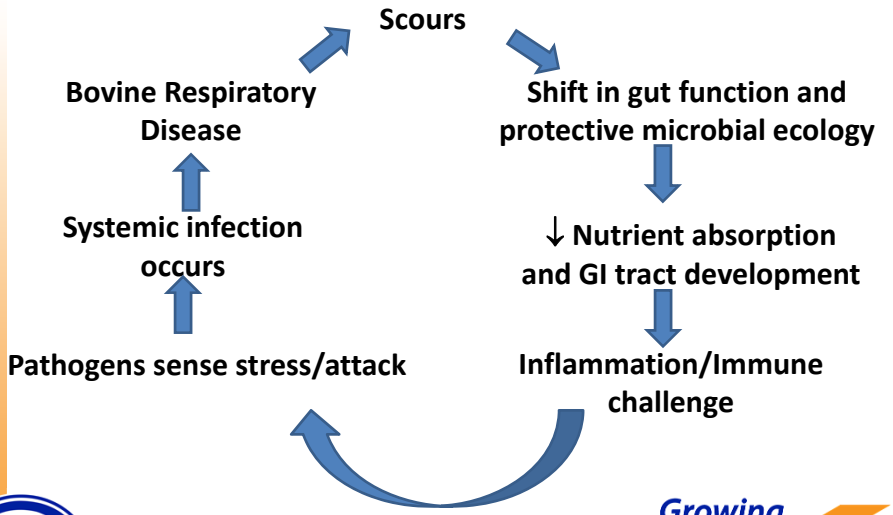
Scours/respiratory cascade



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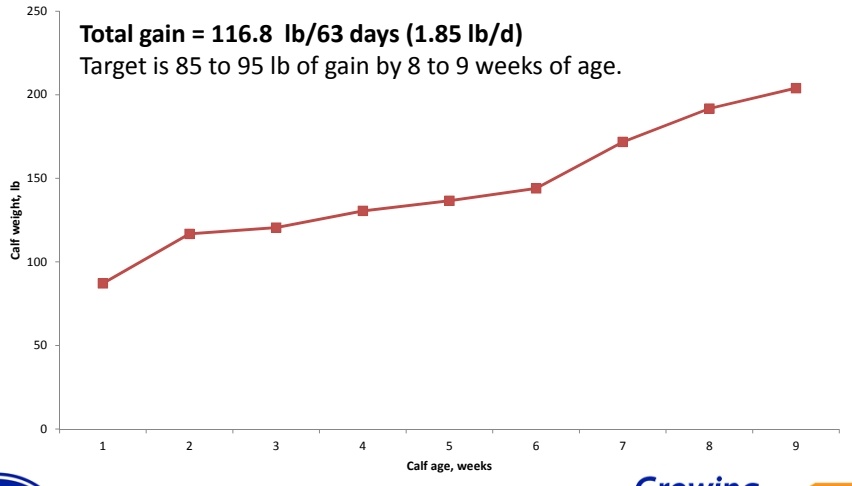
Calves fed 6 quarts/d whole milk, whole milk additive, and quality calf starter

Total gain = 116.8 lb/63 days (1.85 lb/d)

Target is 85 to 95 lb of gain by 8 to 9 weeks of age.



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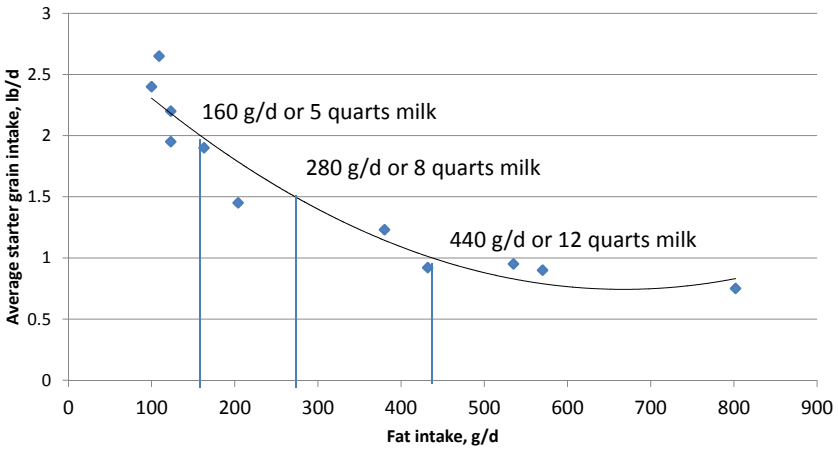
We can feed about 160 g/d milk fat before starter intake averages < 2.0 lb./day



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Why feed elevated fat amounts?

- **Calves in auto-feeder barns can have increased maintenance energy requirements**
  - Cold stress
- **Immune system requires glucose for fuel**
  - Fat spares glucose providing more glucose for immune function.
  - Nursery calves- activated immune system requires approximately 43 g/hour.
- **Increased caloric density for calves consuming small milk meals**
  - 2 quart bottles

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Safe zone calf feeding table

% Milk solids	Milk, quarts/day	Milk quarts/ feeding	Milk solids intake, lb./day	Milk solids intake, oz./feeding	Milk solids intake, % of body weight	Milk fat intake, lb./day
8	3	1	1.0	6	1.0	0.2
10	4	2	1.25	8	1.25	0.3
11	5	3	1.5	10	1.5	0.33
12	6	4	1.75	12	1.75	0.38
13	7	5	2.0	14	2.0	0.44
14	8	6	2.25	16	2.25	0.50
15	9	7	2.5	18	2.5	0.55
16	10	8	2.75	20	2.75	0.61
17	11	9	3.0	22	3.0	0.66

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Thoughts on making feed changes

- **Gradual change over a week.**
- **Expect a 1 to 2 week period of adaptation.**
- **How you feed is as important as what you feed.**
- **Replace qualitative measures with quantitative measures (perception vs. reality).**
- **Heifer feed intake is impacted by:**
  - Health, weather, rate of growth, quality of feed, feeding methods, competition, air quality…..

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Just a pinch of additives

Plasma	Intestinal health and crypto control
Methionine	Amino acid promotes growth and inflammation control
Organic trace minerals	Increased bioavailability for growth and health
Medium chain fatty acids	Antibacterial activity in the abomasum and small intestine
Vitamin C	Antioxidant
B Vitamins	Stimulate appetite and energy metabolism
MOS	Bind some pathogens and stimulate gut immunity
Bacillus strains (DFM)	Clostridium control
Lactobacillus strains (DFM)	Help maintain normal intestinal function
Rumensin/Bovatec/Decox	Cocci control
Clarifly	Inhibits fly maturation

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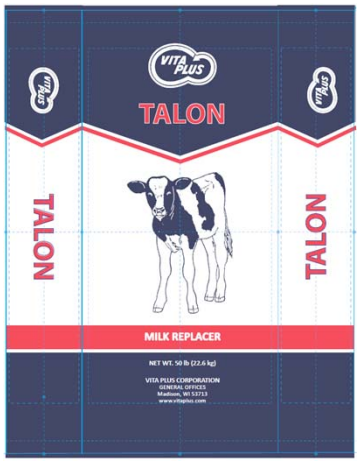
Talon Calf Milk Replacer (25:25)

Attributes
High protein
Plasma
Amino acid balanced
High fat
Medium chain fat from coconut oil
Organic trace minerals
B-vitamins
MOS
Bov/Clar



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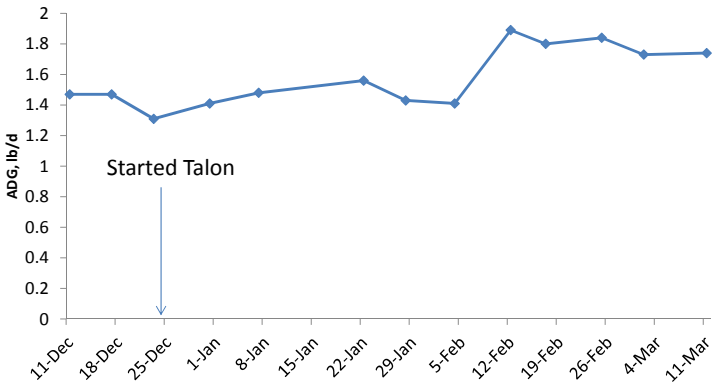
Switching to Talon increased ADG by +0.33 lb ADG



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Calf Magnify (30:5)

- **Pasteurized milk additive, 4 oz/calf/d**
- **Additives:**
  - Bovatec
  - ClariFly
  - MOS
  - Plasma
  - Amino acids
  - Organic TM (Zn, CU, Fe, Mn, and Se)
  - Vitamin A, D, C, E, and B-vitamins

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5-Steps to auto feeder success

1. Excellent maternity management
2. Background calves
3. Prevent under or over-consuming milk
4. Encourage starter grain and water intake
5. Maintain environmental quality

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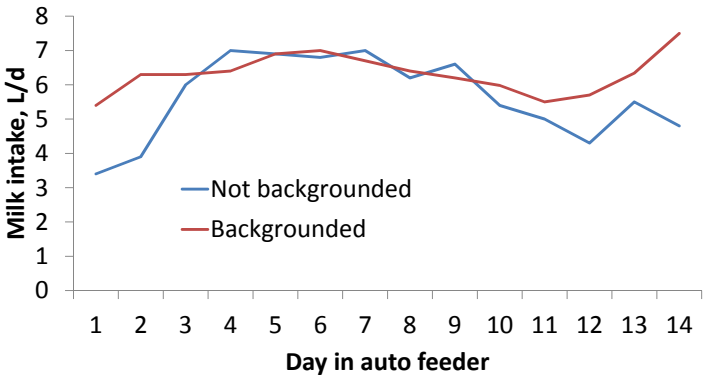
Comparison of milk intake with and without backgrounding



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Predicting problem calves

- Vigor Score- 0h and 24 h
- Birth body weight < 80 lb and > 100 lb
- Total protein < 5.5 and >8.5 mg/dL
- Calving ease > 3
- Slow start on milk/suckle reflex

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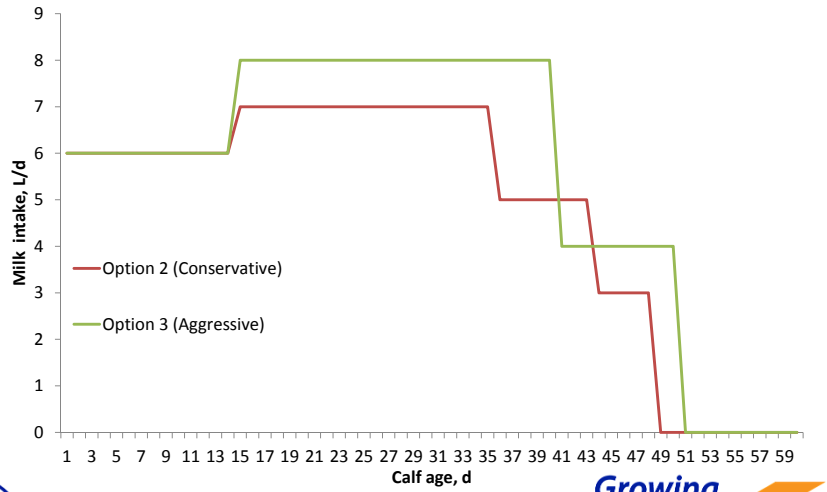
Developing Feeding Curves for Auto Feeder Reared Calves



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Interpreting Calf Behavior

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5 steps to transition calf success

1. **Balanced nutrition approach during nursery phase.**
2. **Minimizing additive effects of stressors.**
3. **Providing adequate resources.**
4. **Manage for consistency understand variation.**
5. **Individual calf management.**

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Problem	Likely Cause	Suggested Solution
Pneumonia	Stress/cortisol	Add only 1 stressor at a time
Fail to thrive	Poor rumen development Low energy intake relative to env't.	5 lb starter intake at weaning and 170+ pounds at grouping Dry beds Increase energy intake
Loose stool	Overfeeding starch Underfeeding fiber	Develop rumen earlier Balance starch and fiber intake Feed a coccidiostat
Firm stool	Low water intake Too high fiber intake	Clean fresh water, hay quality eval/feed bunk mgmt.

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Nursery Calf Vita Score Evaluation

Score	Qualitative	ADG, lb
1	Excellent	>1.8
2	Good	1.5 to 1.7
3	Opportunity for improvement	1.0 to 1.4
4	Struggling	<1.0

A method of evaluating variation in calf performance

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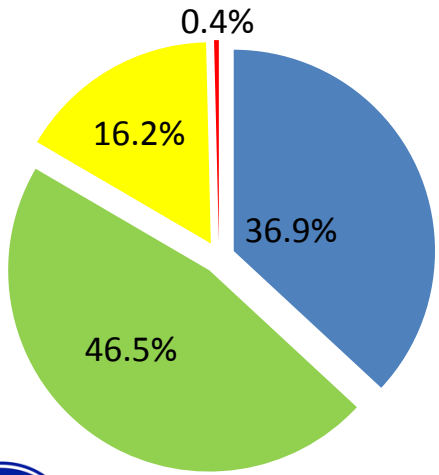
Results: Dairy #1 Nursery Calf Vita Score



ADG	Score	N
>1.8	1	296
1.5 to 1.7	2	373
1.0 to 1.4	3	130
<1.0	4	3
	Total	803

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Results: Dairy #1 Nursery Calf Vita Score

ADG	Score	N	ADG	Days	Gain	Hip Height	Move weight
>1.8	1	296	1.96	64.6	126.1	38.3	208.7
1.5 to 1.7	2	373	1.66	64.1	106.4	37.9	188.0
1.0 to 1.4	3	130	1.35	65.5	89.0	36.8	169.1
<1.0	4	3	0.93	85.7	78.0	36.7	166.0
	Total	803					

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5 key lessons in 5 years

- **Grow calves from the inside out.**
- **Calves have a fiber requirement.**
  - 15% NDF with physically effective fiber
- **Limit milk fat to 1 to 2 sticks of butter/day please.**
- **Auto feeders have allowed us to see calf nutrition from a different angle.**
- **Transition calf success is key.**

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Summer heat stress

- Prop up the back of hutches
- Increase water (and bedding) frequency
- Increase fat feeding rate
- Maintain freshness of grain
- Sand bedding for older heifers
- Free choice electrolytes

Vita Score

Birth Body weight, lb	Calf Weight, lb at day 56										
	150	155	160	165	170	175	180	185	190	195	200
75	1.34	1.43	1.52	1.61	1.70	1.79	1.88	1.96	2.05	2.14	2.23
80	1.25	1.34	1.43	1.52	1.61	1.70	1.79	1.88	1.96	2.05	2.14
85	1.16	1.25	1.34	1.43	1.52	1.61	1.70	1.79	1.88	1.96	2.05
90	1.07	1.16	1.25	1.34	1.43	1.52	1.61	1.70	1.79	1.88	1.96
95	0.98	1.07	1.16	1.25	1.34	1.43	1.52	1.61	1.70	1.79	1.88
100	0.89	0.98	1.07	1.16	1.25	1.34	1.43	1.52	1.61	1.70	1.79
105	0.80	0.89	0.98	1.07	1.16	1.25	1.34	1.43	1.52	1.61	1.70
110	0.71	0.80	0.89	0.98	1.07	1.16	1.25	1.34	1.43	1.52	1.61

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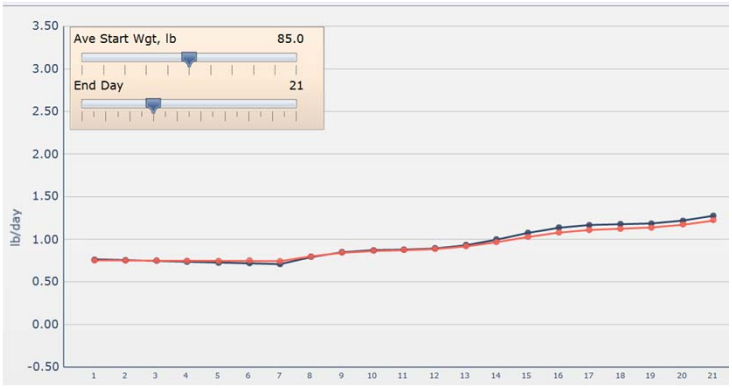
Whole milk 4 quart

Energy and protein allowable gain are perfeclty balanced- very efficient!

When it gets cold out, calves will need more energy to take advantage of the protein



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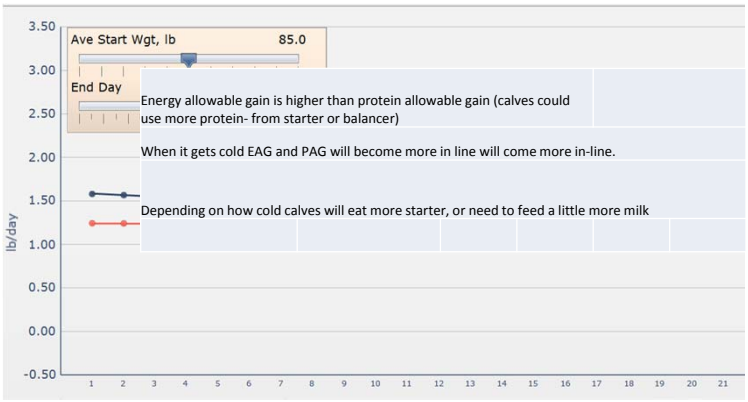
Whole milk 6 qt/d example



Energy allowable gain is higher than protein allowable gain (calves could use more protein- from starter or balancer)

When it gets cold EAG and PAG will become more in line will come more in-line.

Depending on how cold calves will eat more starter, or need to feed a little more milk

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Impact of weight at transition on DMI potential

ADG (85 lb BBW)	56 d 8 wks	Intake 4% BW	70 d 10 wks	Intake 4% BW
1.2	152	6.1	169	6.8
1.4	163	6.5	183	7.3
1.6	175	7.0	197	7.9
1.8	186	7.4	211	8.4

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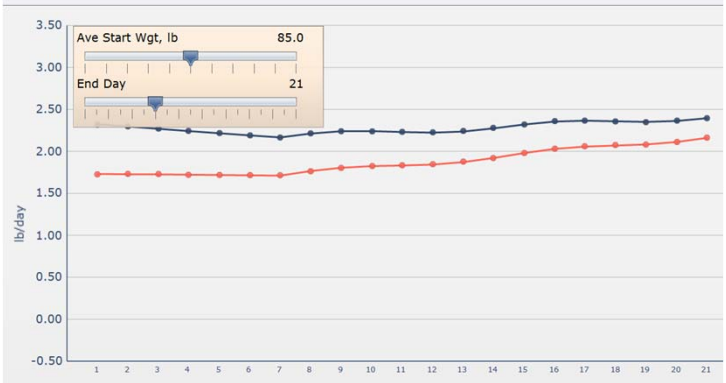
Whole milk 8 quart

8 qt example Way overfeeding energy relative to protein, calves will not be hungry for starter, withought the microbial protein, protein allowable gain becomes more limiting.



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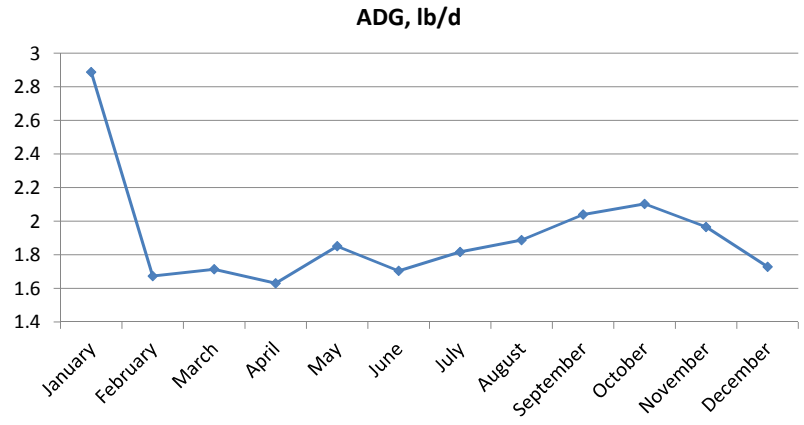
ADG is at a very respectable 1.83 lb/d if we exclude January values. Performance this past Aug. to Nov. was excellent



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Consider calves like these high risk for future health challenges

Swollen face indicates prolonged delivery

Manure indicates calf has a high likelihood of developing a navel and or systemic infection

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Mechanism by which cottonseed hulls function in the calf

- Rumen papillae development
- Increase water intake
- Increase bulk and fill in the rumen
- Alter hindgut fermentation
- Slow down the rate of passage

Calf physiological response to nutrition

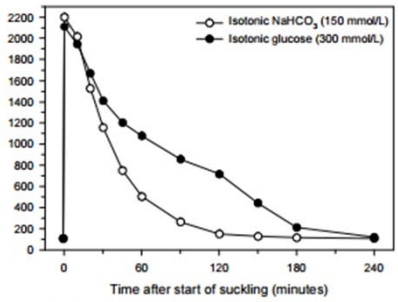

Figure 2. **Change in abomasal volume after suckling 2 L of isotonic solution of sodium bicarbonate (open circles) or glucose solution (filled circles) at time = 0 minutes**

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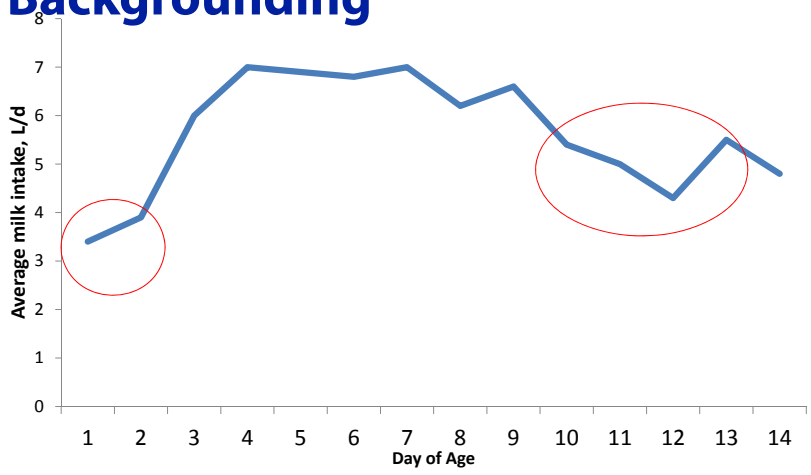
Fat Intake, g/d for varying milk feeding rates

		% fat in milk solids		
Quarts of Milk	Lb Milk Solids	20	25	31
4	1.0	91	113	140
6	1.5	136	172	213
8	2.0	181	227	281
10	2.5	227	286	354

Texturized Starter		Pelleted Starter	
Advantages	Disadvantages	Advantages	Disadvantages
Greater intake	Higher risk for feed sorting than pelleted starter	Cost	Lower starch, fat, and energy content than texturized feed
Greater nutrient digestibility	Less chemical fiber (NDF) than pelleted starter but more effective fiber.	Grain handling	Decreased saliva production Reduced feeding time Reduced ruminating time
Start ruminating at a younger age/More functional fiber to stimulate rumination	Some reports of corn in starter attracting more nuisance birds	Grain processing might increase digestibility of some ingredients	Requires specialized manufacturing equipment-Pellet integrity
Minimize fines	Higher molasses may invite more flies	Lower starch Reduced feed sorting	Limitations on ingredients and ingredient amounts
Allows for feeding of processed or whole grains (whole corn, rolled corn, steam flaked corn)		Decreased molasses associated fly challenges	Increased grain processing may increase rate of passage and decrease total tract digestibility

Total Milk Intake, L/d Without Backgrounding



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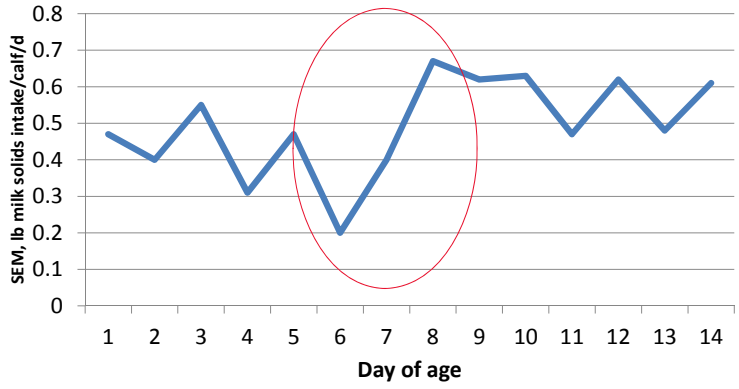
Standard error of the mean for solids intake expressed as a percentage of birth body weight



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Comparison of calf starter physical form (pellet vs. texturized); Porter et al., 2007. Bull calves were fed the same milk replacer, housed in elevated crates with no bedding, and weaned at twenty-seven days of age.

	Treatments			
	Pellet	Texturized	Standard Error	P-Value
5 to 8- Week gain, lb	28.4	36.4	0.13	< 0.05
5 to 8- Week starter intake, lb	84.3	100.4	10.9	< 0.05
Week first ruminating	6.0	3.7	---	< 0.05
% time spent ruminating	8.7	21.0	---	< 0.05
Rumen pH	5.0	5.4	---	NS
DM digestibility, %	71.3	76.3	---	< 0.05
NDF digestibility, %	39.7	51.9	---	< 0.05

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Corn Processing Evaluation

	Kibbled Corn	Steam Flaked Corn	Whole corn
Starch digestibility, %	91.1	84.1	80.9

	Control	BSF 18
NDF, %	11.0	15.9
NDFd, 24 h	35.3	47.8
NDFd, 48 h	54.7	66.3
uNDF, 24 h	6.9	8.2
uNDF, 48 h	4.8	5.3

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Factors influencing amount of fines

Manufacturing:

- **Ingredient selection and quality (PDI, season and storage length).**
- **Cleanliness of leg and mixer (flush and screens)**
- **Size of batch vs type of mixer and mixing time**
- **Amount of liquid and rate of addition**
- **Bulk vs. bag**

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Factors influencing amount of fines

Delivery:

- **Cleanliness of the truck at onboarding**
- **Run first 25 pounds as flush**
- **Auger- size, length, speed, angle, amount of fill, and spacing on flighting**
- **Cleanliness of bin**

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Nutritional scours control

- **Consider feeding programs that reflect the calf's body weight and environmental temperature.**
- **Start calves out slowly and then step them up to higher feeding rates.**
- **Calves that develop a moderate to severe case of scours may not gain weight for a week during the time in which their hydration status is recovering and they are remodeling damage done to their GI tract.**
  - Impaired absorptive capacity and altered gut microbial ecology.

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Getting calves off to the right start

- **Minimize disease exposure**
  - Multiplier effect in group housing
- **Colostrum**
  - Insulin and other growth factors to mature the gut
  - Allows calf to digest larger volumes of milk (> 6 L/d)
- **Backgrounding-4 to 6 feedings.**
- **Introduce into the feeder at their next scheduled meal and coach calves for the first feeding.**

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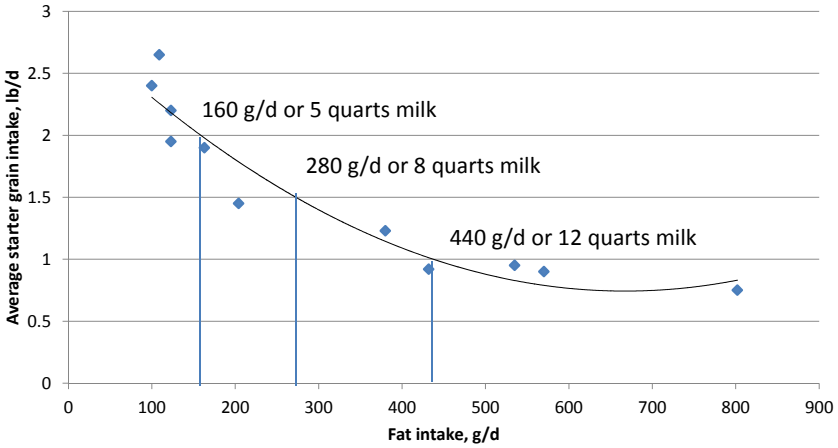
We can feed about 160 g/d milk fat before starter intake averages < 2.0 lb/d



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Inclusion of cottonseed hulls into starter grain increased calf performance

Item	Control Starter	Control + 15% Cottonseed hulls	P-value
Starter intake, lb/d	1.67	1.98	0.01
ADG, lb/d	1.1	1.3	0.02
Wither height	30.9	30.9	0.84
Fecal Score	1.34	1.25	0.03

Hill et al., 2009

Notes:
58 calves/trt

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Energy and protein source changes with age

Developmental Stage	Energy/protein Substrate	Source
Fetal	Glucose/amino acids	Maternal blood
Pre-ruminant (milk fed)	Glucose and LCFA/milk protein	Milk lactose and fat/Milk whey and casein
Ruminant	VFA's and fat/microbial protein and feed protein	Rumen fermentation/ Grain and forages

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Factors influencing amount of fines

- **Feed-out**
  - Drop bottom bin vs. auger
  - Auger- short, flat, large diameter
  - Rate of use
  - Temperature, humidity, quality of seals on bin
  - Cleaning out buckets regularly

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Starter Grain-Challenges

- **Fines-**
  - Each pass through an auger generates ~5% fines
  - Molasses is absorbed as the starter ages resulting in a drier look and typically more fines separation
  - Quality of corn will impact fines
    - Corn from a grain dryer will typically be more brittle with increased drying time
  - Corn processing
    - Whole < rolled < cracked < ground
    - Screening prior to blending will likely be required

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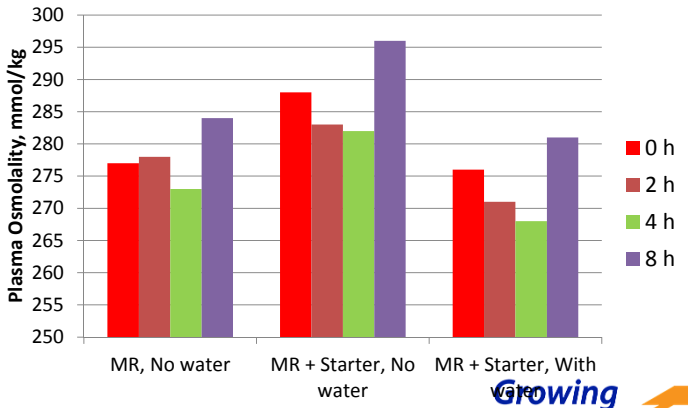
Water Balance in Nursery Calves

	Milk Replacer	Milk replacer + Dry feed	
	No water	No water	With water
Urine osmolality, mmol/kg	450	1007	527



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A gallon of whole milk fails to meet the calf's trace mineral requirements

Mineral	NRC, 2001 Requirement, mg	Milk, mg	% of NRC supplied
Manganese	18.1	0.13	0.7
Zinc	18.1	12.0	66.0
Copper	4.5	0.27	6.0
Iron	45.4	1.2	2.6
Cobalt	0.05	0.002	4.0
Selenium	0.13	0.14	107.0
Iodine	0.23	0.07	30.0

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A gallon of whole milk fails to meet the calf's vitamin requirement

Mineral	NRC, 2001 Requirement, IU	Milk, IU	% of NRC supplied
Vitamin A, IU	5,218	5216	100
Vitamin E, IU	23	3.6	16
Vitamin D3, IU	272	139	51
Thiamin, mg	2.9	1.6	54
Niacin, mg	4.5	4	88
Pyridoxine, mg	2.9	1.6	54
B12, mcg	31.8	17.2	54
Folic Acid, mg	0.23	0.2	87

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Pasteurized Milk Additives

No Additive	VTM Pack	Milk Balancer	Calf Magnify
-No cocci control **-Deficient in trace minerals and vitamins** **-No MOS** **-No Plasma** **-282 mOsm/kg**	-No cocci control -Still deficient in trace minerals and vitamins -No MOS -No Plasma	-8 oz /d ->15% solids -Protein blend -483 mOsm/kg	-4 oz/d -High protein:Low fat -30:5 -Increases solids by 1.5% -352 mOsm/kg

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Early starter intake promotes GI tract development

Pearson correlations between starter intake and maturity of gastrointestinal development.

	250g/d	500g/d	1000g/d	2000g/d
SMI length	-0.71*	-0.63*	-0.66*	-0.64*
Empty RR weight	-0.29	-0.46*	-0.47*	-0.67*
Empty O weight	-0.31	-0.43**	-0.28	-0.21
Day 56 gain	-0.60*	-0.72*	-0.63*	-0.63*

*Indicates a value of $P \leq 0.05$
** Indicates a value of $0.05 < P \leq 0.10$

LaBerge Master's Thesis

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Microbial Ecosystem Establishment

- **In all neonates studied, initial/early microbial establishment sets the stage for microbial population throughout the animals life.**
- **USDA study:**
  - Swapped rumen contents from between cows
  - Microbial populations migrated back to the original profile within a few days.
  - Microbial population is part of the breed definition
    - Not practical to induce a major shift in microbial populations

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Growing Tomorrow's Herd