LIFESTART Science

Our journey to unlock the potential of dairy calves

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In 2012 Trouw embarked in a fascinating research journey

LIFESTART
SETS LIFE PERFORMANCE

- More than 30 peer review publications
- 3 patent families
- 4 new products
- New feed protocols and formulations

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Cornell University

afbi Agri-Food and Biosciences Institute

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WASHINGTON STATE UNIVERSITY

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IRTA RESEARCH & TECHNOLOGY FOOD & AGRICULTURE

UNIVERSITY OF ALBERTA

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

agresearch
Farming, Food and Health. First

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Glossary of terms

EPIGENETICS

METABOLIC PROGRAMMING

PHENOTYPICAL PLASTICITY

SILVER SPOON EFFECT

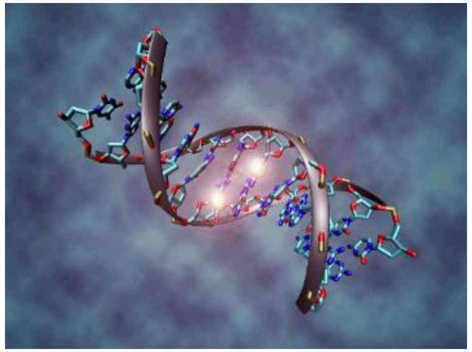
THRIFTY PHENOTYPE

METABOTYPE

WINDOW OF OPPORTUNITY

Hunger epigenetics

- “Hongerwinter” Dutch famine Amsterdam 1944/45
- Long term correlation with metabolic syndrome
- Great Chinese famine 1958 and Biafra 1968



Picture Christoph Bock, Max Planck Institute

Picture Menno Huizinga

- Effects mediated by difference in DNA methylation associated to perinatal environment

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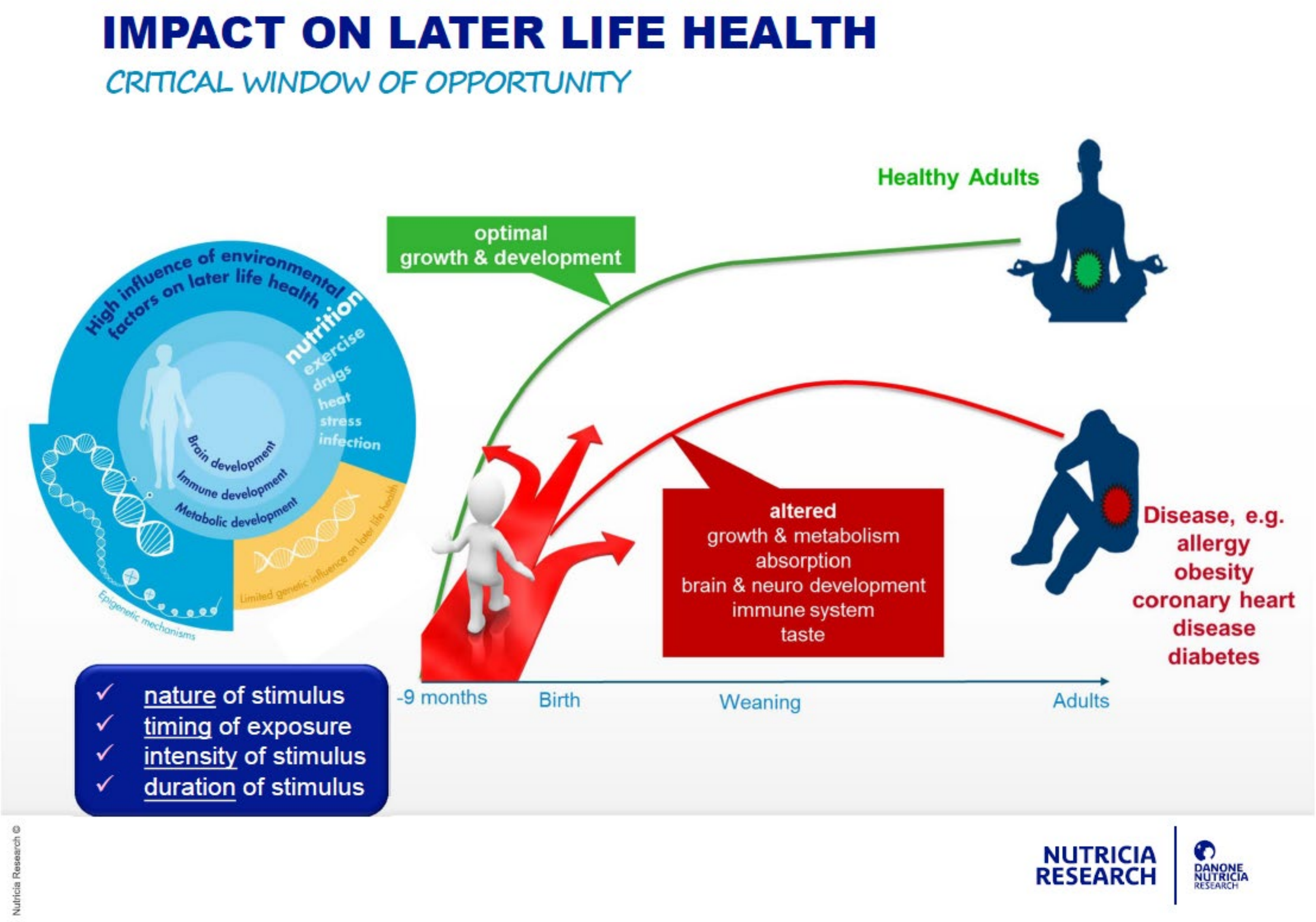

DANONE NUTRICIA
Early Life Nutrition

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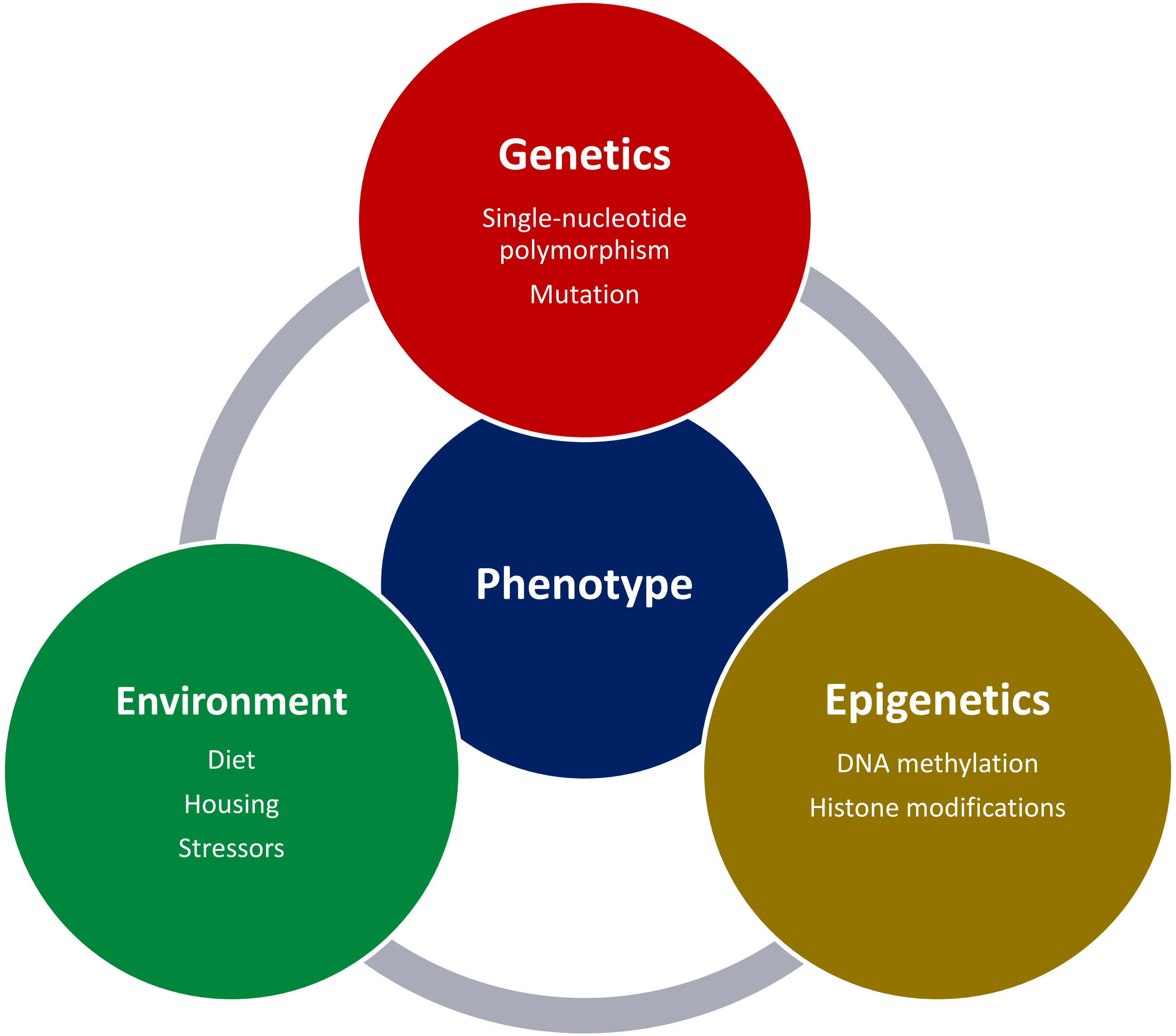
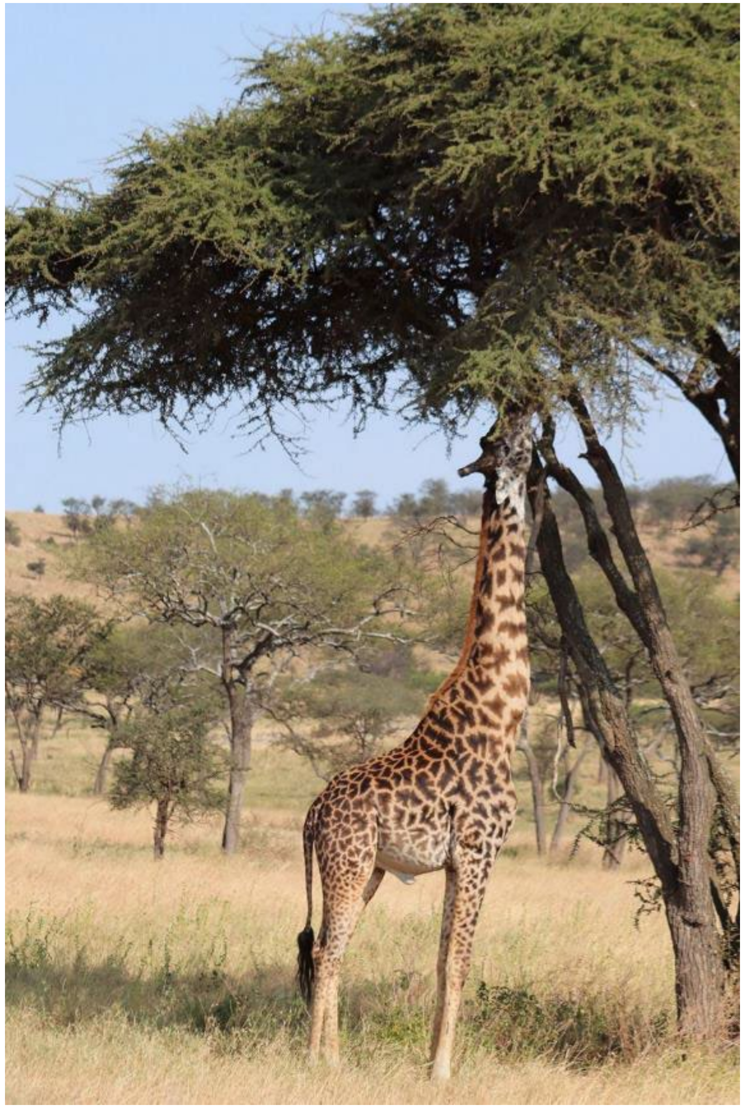
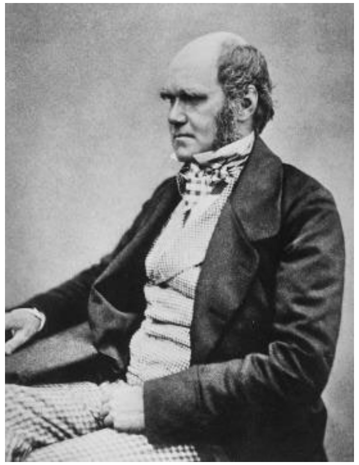
EPIGENETICS enter the equation PHENOTYPE = GENETICS + ENVIRONMENT



Lamarck's "I told you" moment came a bit too late

Jean-Baptiste Lamarck





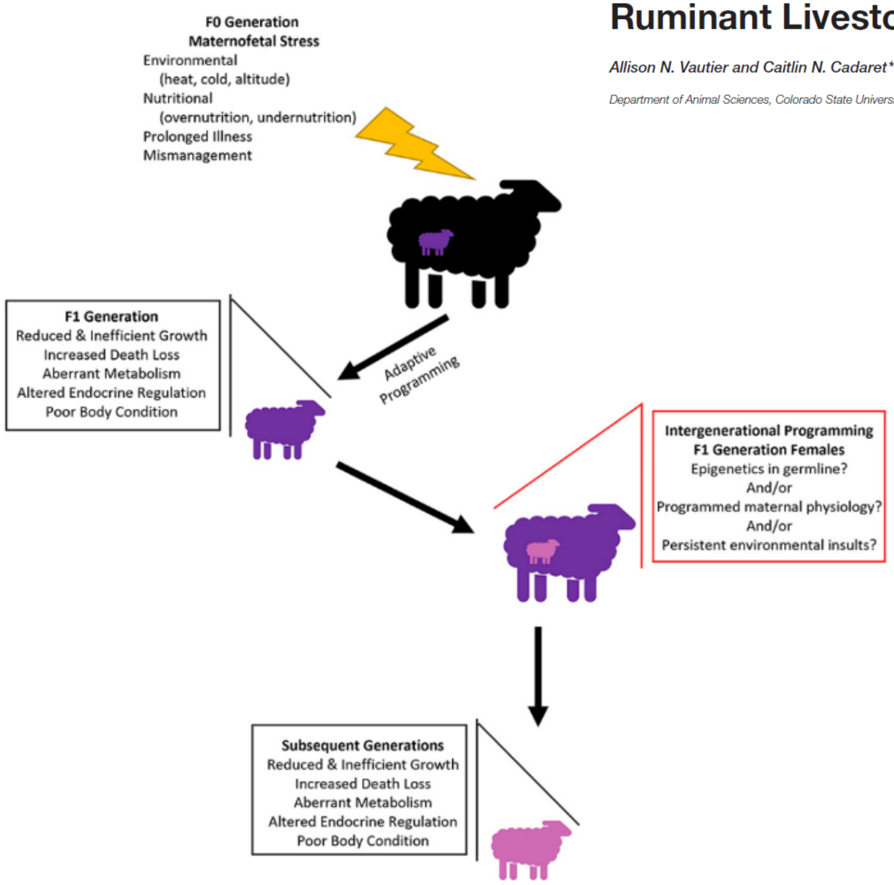
Charles Darwin

Adaptations can indeed persist through generations

Long-Term Consequences of Adaptive Fetal Programming in Ruminant Livestock

*Allison N. Vautier and Caitlin N. Cadaret**

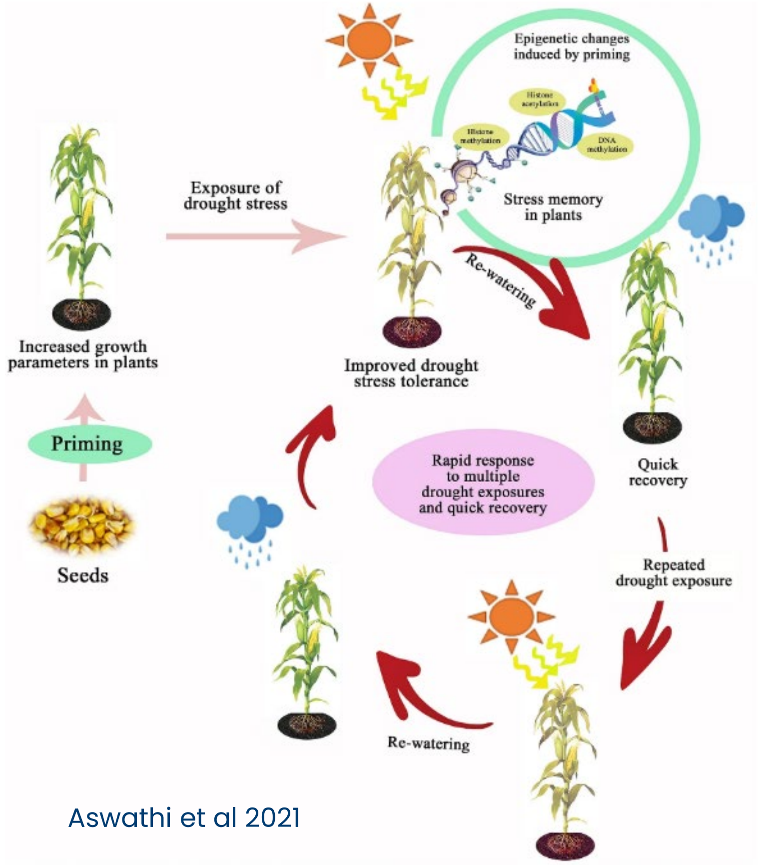
Department of Animal Sciences, Colorado State University, Fort Collins, CO, United States



Vautier and Cadaret 2022

Seed priming of plants aiding in drought stress tolerance and faster recovery: a review

K. P. Raj Aswathi[1] · Hazem M. Kalaji[2] · Jos T. Puthur[1]



Aswathi et al 2021

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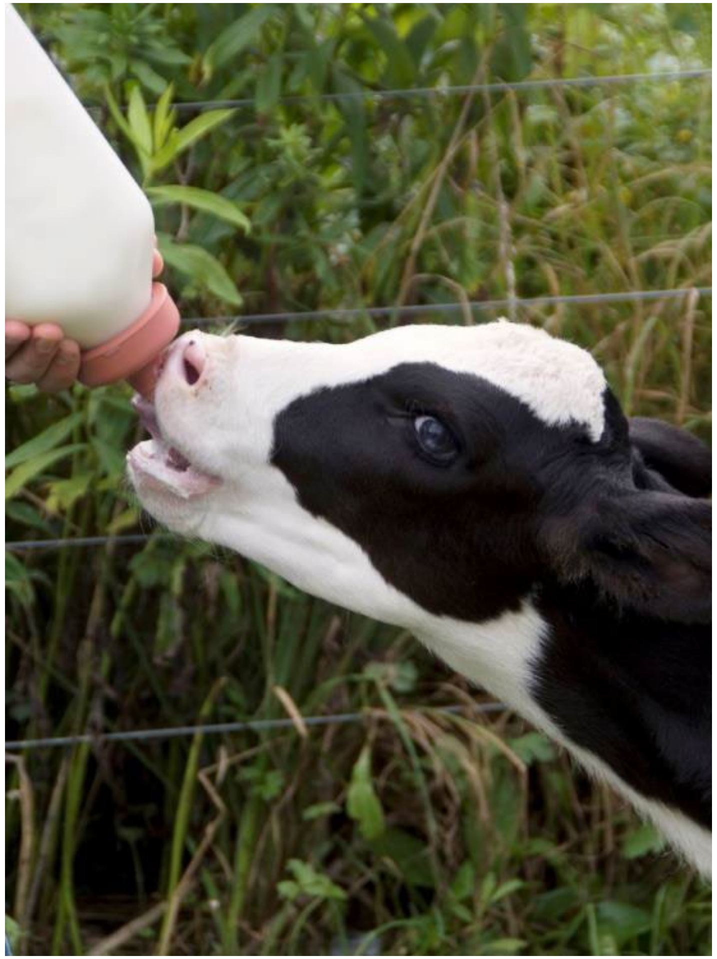
Dairy calves, the perfect thrifty phenotype model



"Perinatal nutrient deprivation sets adult metabolism for scarcity not for abundance"

What are the biological needs of a calf?

Dairy calves

125l/250l/500l
Weaning at 6/8/12 weeks

- Colostrum
- Health
- Peer and maternal contact
- Ad libitum milk
- Bovine milk composition
- Gradual weaning

Market research* has shown that more than 65% of farms are only feeding 6 litres or less of whole milk or calf milk replacer to their calves.

Survey Trouw Nutrition Great Britain, 2022

Biological reference

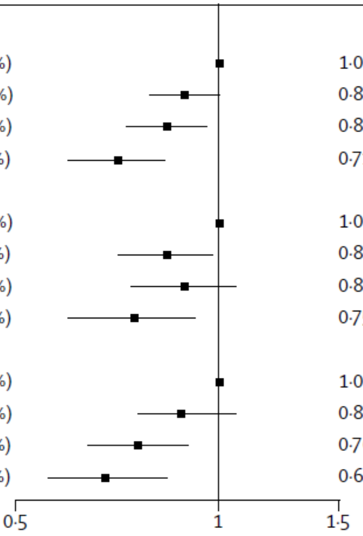
1.500l
Weaning at 6 months

Milk’s effect on global human health

- Prospective cohort study 21 countries from five continents (PURE)
- From 2003 to 2028. 136.000 subjects, 7.000 deaths, 6.000 cardiovascular events

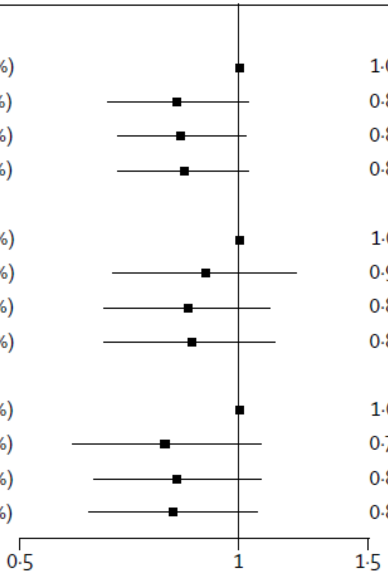
Consumption of only whole-fat dairy

	n	Events	HR (95% CI)	P_{trend}
Composite outcome				0·0001
<0·5 servings per day	12 399	968 (7·8%)	1·00 (1·00–1·00)	
0·5–1 servings per day	12 023	789 (6·6%)	0·89 (0·79–1·00)	
1–2 servings per day	8853	519 (5·9%)	0·84 (0·73–0·96)	
>2 servings per day	7552	430 (5·7%)	0·71 (0·60–0·83)	
Total mortality				0·01
<0·5 servings per day	12 399	547 (4·4%)	1·00 (1·00–1·00)	
0·5–1 servings per day	12 023	374 (3·1%)	0·84 (0·71–0·98)	
1–2 servings per day	8853	317 (3·6%)	0·89 (0·74–1·06)	
>2 servings per day	7552	248 (3·3%)	0·75 (0·60–0·92)	
Major cardiovascular disease				0·0001
<0·5 servings per day	12 399	624 (5·0%)	1·00 (1·00–1·00)	
0·5–1 servings per day	12 023	538 (4·5%)	0·88 (0·76–1·06)	
1–2 servings per day	8853	308 (3·5%)	0·76 (0·64–0·90)	
>2 servings per day	7552	278 (3·7%)	0·68 (0·56–0·84)	



Consumption of both whole-fat and low-fat dairy

	n	Events	HR (95% CI)	P_{trend}
Composite outcome				0·24
<0·5 servings per day	3297	207 (6·3%)	1·00 (1·00–1·00)	
0·5–1 servings per day	4074	232 (5·7%)	0·82 (0·66–1·03)	
1–2 servings per day	9340	483 (5·2%)	0·83 (0·68–1·02)	
>2 servings per day	17 276	916 (5·3%)	0·84 (0·68–1·03)	
Total mortality				0·33
<0·5 serving per day	3297	130 (3·9%)	1·00 (1·00–1·00)	
0·5–1 servings per day	4074	153 (3·8%)	0·90 (0·67–1·20)	
1–2 servings per day	9340	262 (2·8%)	0·85 (0·65–1·10)	
>2 servings per day	17 276	485 (2·8%)	0·86 (0·65–1·12)	
Major cardiovascular disease				0·30
<0·5 serving per day	3297	116 (3·5%)	1·00 (1·00–1·00)	
0·5–1 servings per day	4074	131 (3·2%)	0·79 (0·59–1·07)	
1–2 servings per day	9340	303 (3·2%)	0·82 (0·63–1·07)	
>2 servings per day	17 276	552 (3·2%)	0·81 (0·62–1·06)	



Dehghan et al. The Lancet 2018

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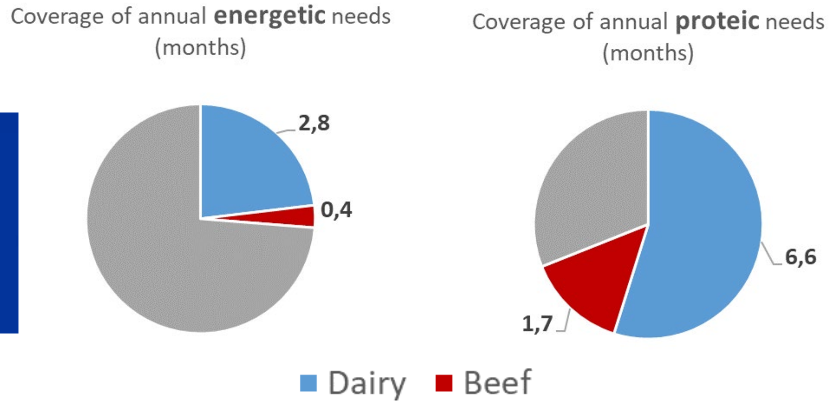
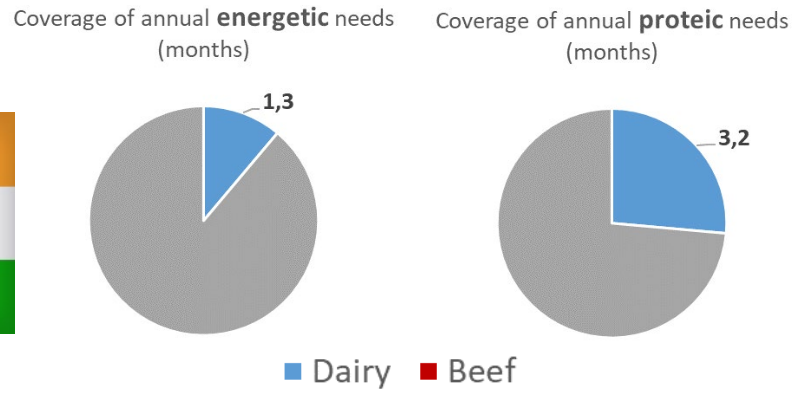
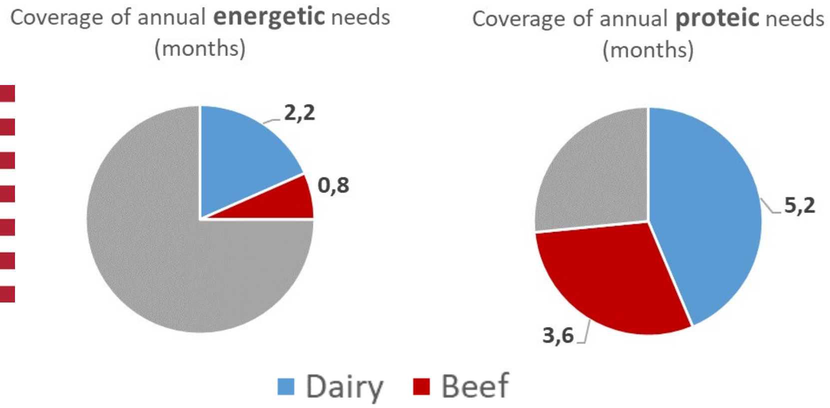
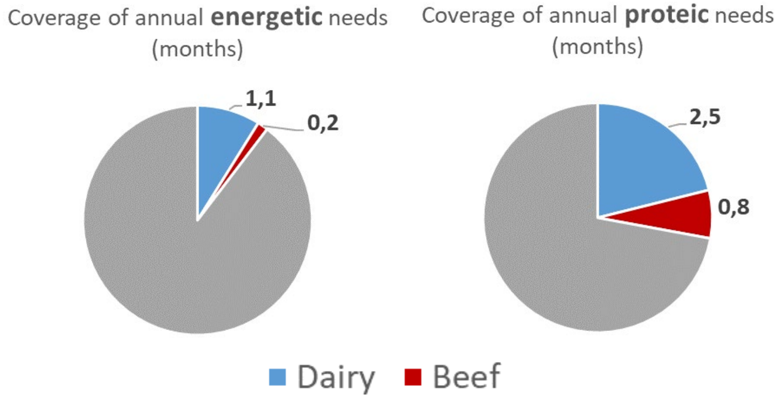
Adjusted for age, sex, education, urban or rural location, smoking status, physical activity, history of diabetes, family history of cardiovascular disease, family history of cancer, and quintiles of fruit, vegetable, red meat, starchy foods intake, and energy.

Bovines contribute to our food security









Milk and beef carcass available estimated by production minus exports. Food available without accounting for food waste.
Meat in carcass assumed 65%. Daily calorie requirement assumed 2250kcal and protein requirement 52g.

Milk from a nutritional angle

... is the ultimate balanced food

A complex food in which nothing is left to chance

- Nutrient transfer role
- Signaling role
- Unique composition by species

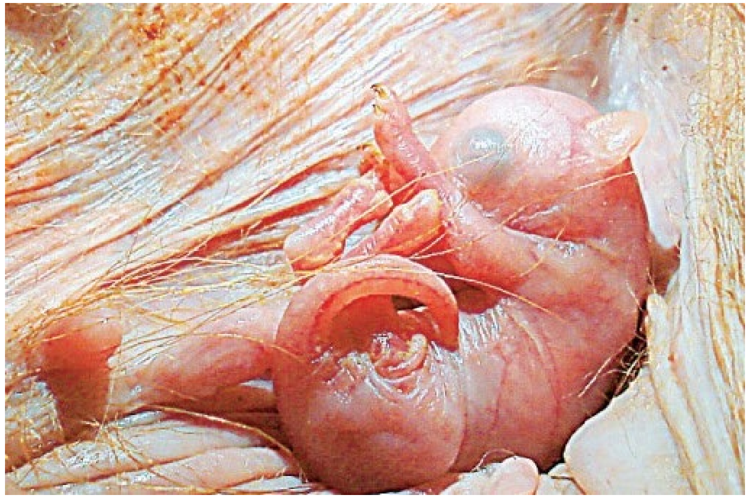
Table 1. Summary statistics of milk traits

Trait	Mean	Minimum	Maximum	CV, %
Yield, kg/d				
Milk	27.45	3.70	51.00	27.87
Lactose	1.31	0.17	2.61	28.57
Composition, %				
Lactose	4.76	4.06	5.46	3.36
Casein	2.66	1.84	3.53	10.53
Protein	3.38	2.22	4.53	11.24
Fat	4.02	2.10	5.94	15.67
Freezing point, °C	−0.525	−0.552	−0.498	1.90
SCS	2.92	−3.64	10.22	60.27
Mineral content, mg/kg				
Calcium	1,317.00	823.10	1,821.15	12.03
Phosphorus	928.76	600.68	1,258.75	11.48
Magnesium	138.47	62.29	193.87	19.14
Potassium	1,505.24	1,102.00	1,909.11	8.54
Sodium	427.05	273.52	581.59	11.75

Costa et al. 2019

- Much older and evolutionarily conserved than placental reproduction

Yes, an older reproductive mechanism



Nutrient supply seems simple, signaling is not

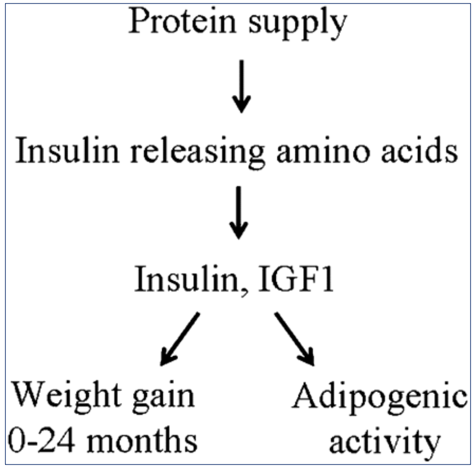
Replacing human milk with bovine milk ingredients

CHOP study: Prospective randomized/cohort 990 infants

2002-2008 nutrient intakes and growth up to age 2

Health monitored up to age 8

Rapid gain weight from high protein intake is linked with childhood obesity



Koletzko et al. 2009

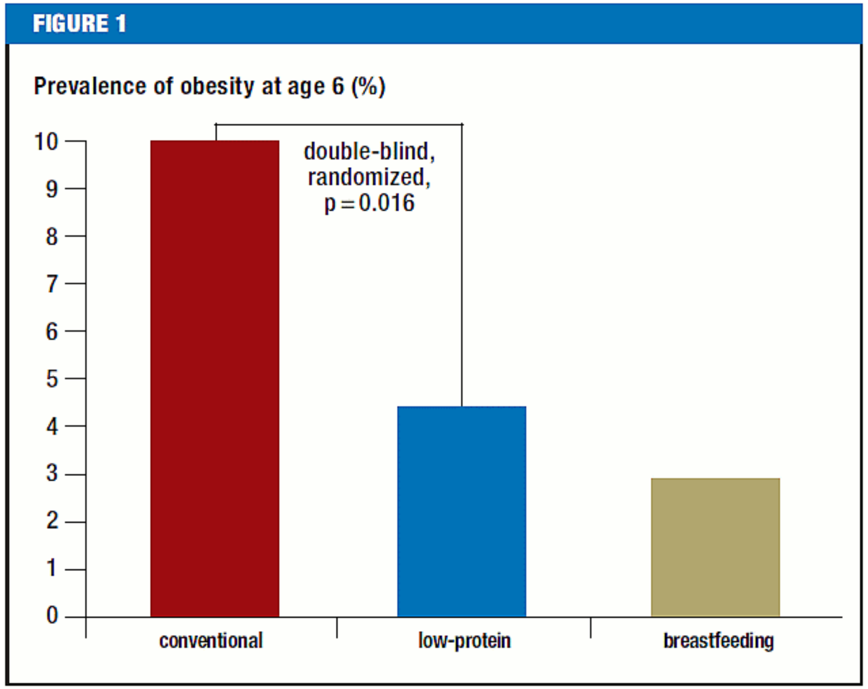


Figure: Ärzteblatt International

Replacing milk is not just putting nutrients in a liquid feed

- Physicochemical properties
- Digestibility
- Glycaemic signals
- Digestion dynamics
- Barrier function
- Protein quality
- Acid/base metabolism
- Gastrointestinal ecology

LIFESTART SETS LIFE PERFORMANCE

Strong (even causal) evidence of benefits

Onset of puberty [4]
Survival until 1st calving [6]
Reduced age at 1st calving [1, 3]
Increased milk production [1, 2, 3, 4, 5]

But how???

[1]Bar-Peled et al. 1998; [2]Drackley et al. 2007; [3]Raeth-Knight et al. 2009
[4]Davis-Rincker et al. 2011; [5]Soberon et al. 2012; [6]Van de Stroet et al. 2016

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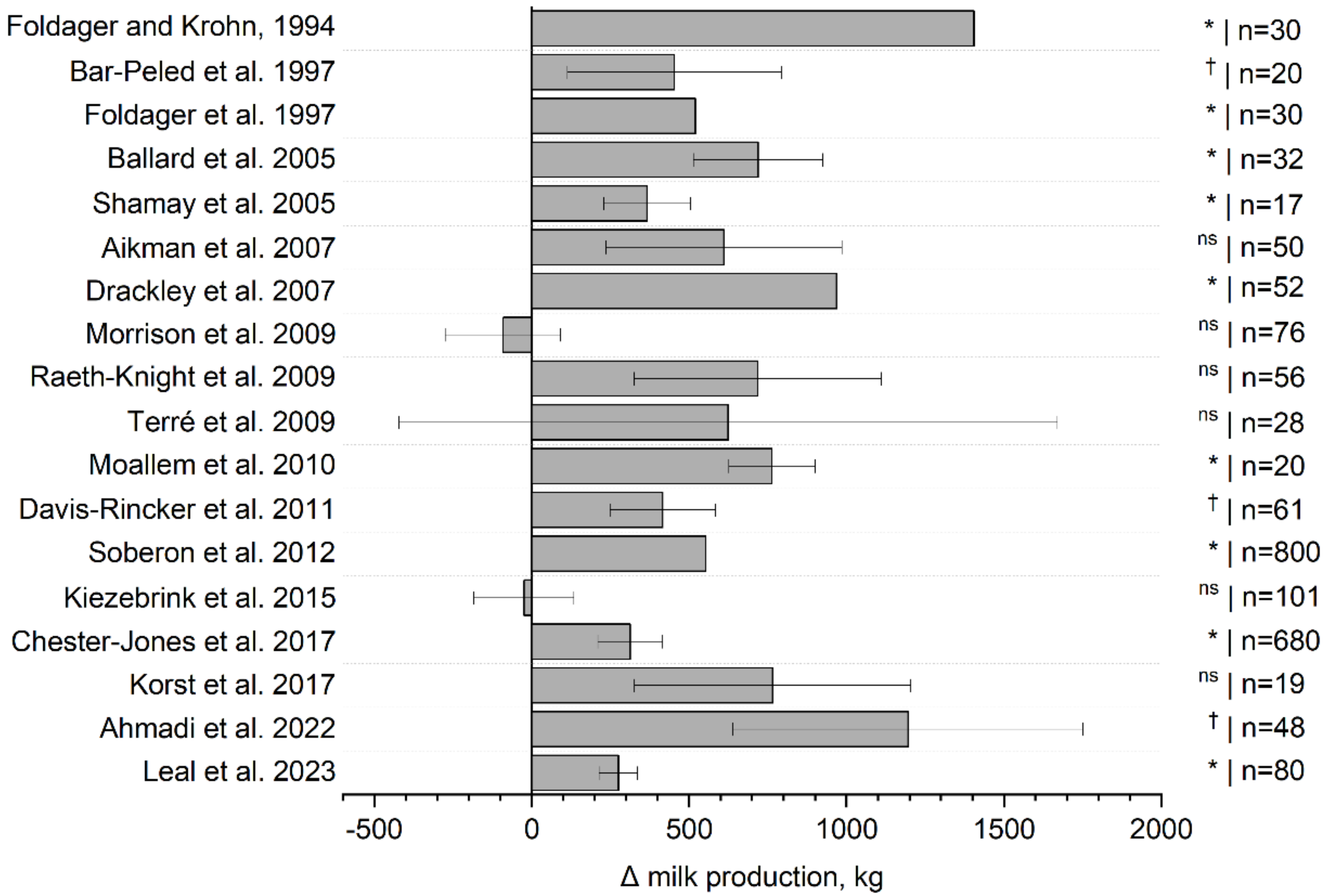
Preweaning growth and 1st lactation milk production



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LifeStart mechanism and metabotype hypothesis

LIFESTART
SETS LIFE PERFORMANCE

Grams of daily gain that turn into future litres of milk

How does this happen?

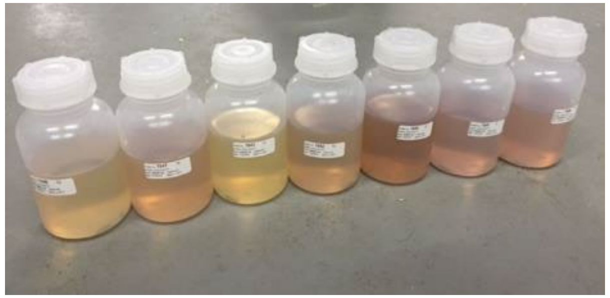
- Simply through development?
- Or really through metabolic programming?

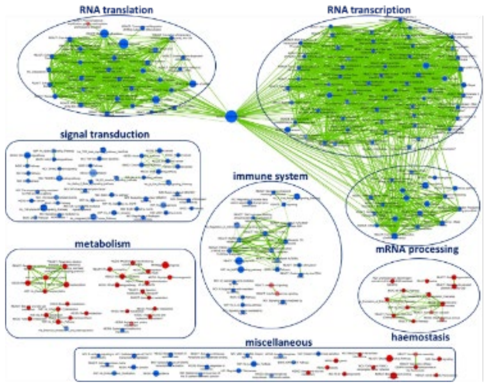
Nutrients or signals?

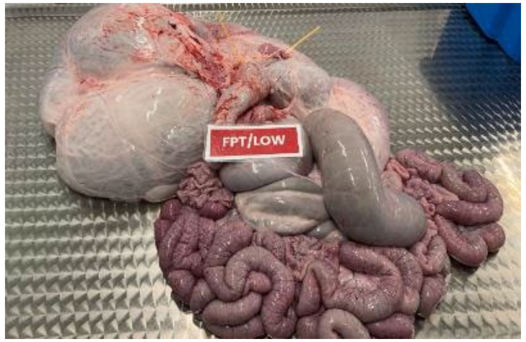
- Nutrient building blocks?
- Signals messaging?

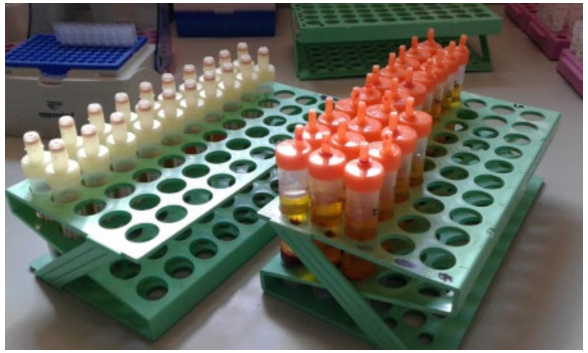
Research toolset

- Nutrient digestibility
- Total nutrient balance
- Transcriptomics
- Metabolomics
- Insulin sensitivity
- Abomasal emptying
- Intestinal permeability
- Respiration chambers
- Histology
- Total body composition







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Enhanced milk supply and organ development

RESTRICTED: 0.6 kg/d MR

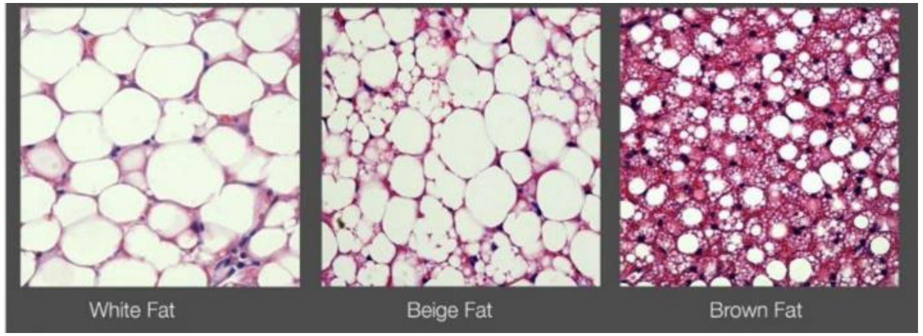
ENHANCED: 1.3 kg/d MR

	Restricted (n=6)	Enhanced (n=6)	P value
Pancreas, g	32.90	29.47	0.61
Pancreas, % of BW	0.06	0.04	0.11
Liver, kg	1.35	2.35	< 0.01
Liver, % of BW	**2.23**	**2.84**	**< 0.01**
Mammary gland, g	75.48	337.58	< 0.01
Parenchyma, g	1.10	6.48	< 0.01
Parenchyma, % of BW	**0.002**	**0.008**	**< 0.01**

(Soberon and Van Amburgh, 2011)

Change in gene expression profiles

	Changed ($P < 0.01$)
Mammary	654
Fat	1045
Liver	176
Bone marrow	435
Muscle	651
Pancreas	103



PLOS | ONE

RESEARCH ARTICLE

Nutrient supply alters transcriptome regulation in adipose tissue of pre-weaning Holstein calves

Leonel N. Leal[1☯*], Josue M. Romao[2☯], Guido J. Hooiveld[3], Fernando Soberon[4], Harma Berends[1], Mark V. Boekshoten[3], Michael E. Van Amburgh[5], Javier Martín-Tereso[1], Michael A. Steele[2*]

J. Dairy Sci. 102:1–13
https://doi.org/10.3168/jds.2018-15699

Preweaning nutrient supply alters mammary gland transcriptome expression relating to morphology, lipid accumulation, DNA synthesis, and RNA expression in Holstein heifer calves

K. S. Hare,[1*] L. N. Leal,[2*] J. M. Romao,[3] G. J. Hooiveld,[4] F. Soberon,[5] H. Berends,[2] M. E. Van Amburgh,[6] J. Martín-Tereso,[2] and M. A. Steele[1]†
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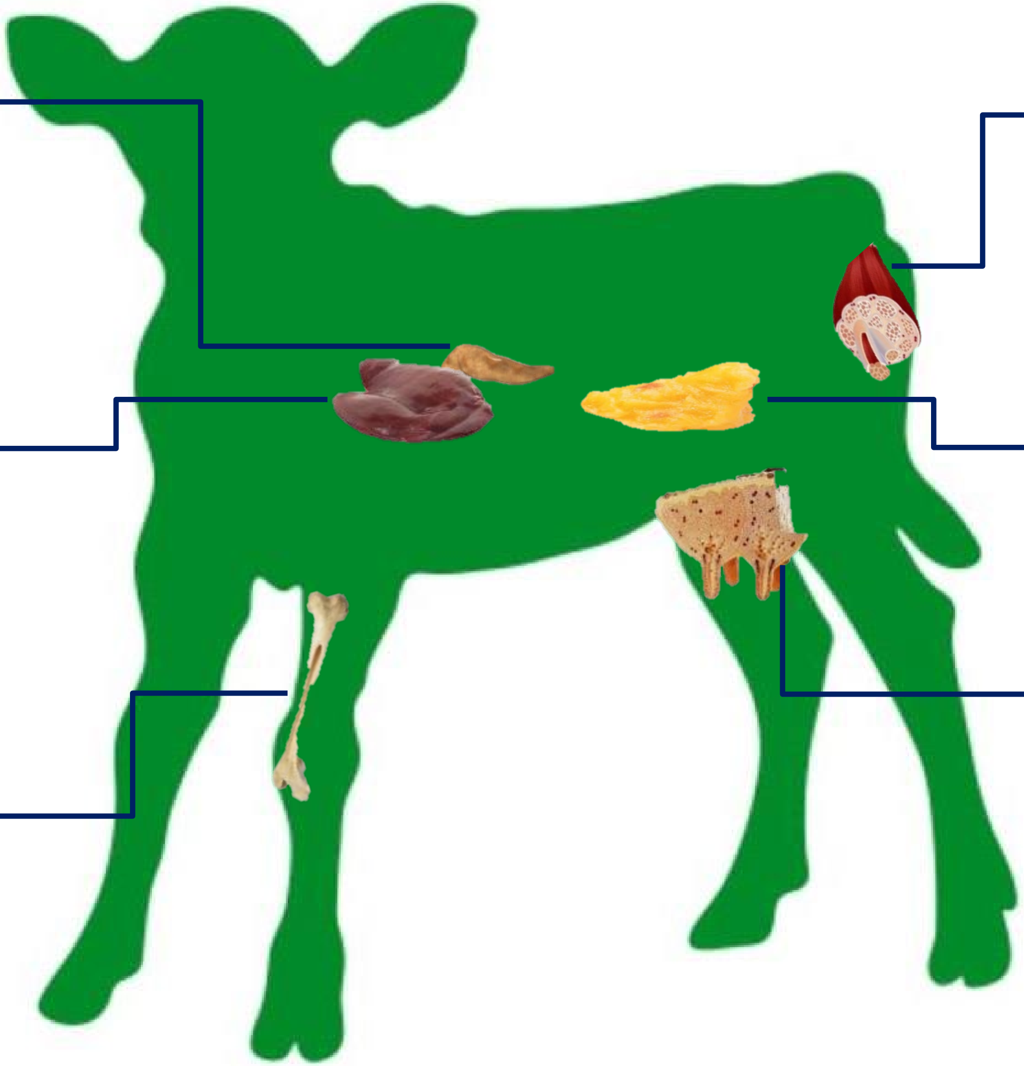
Trouw Nutrition R&D,
Leal et al., 2016, 2017, 2018; Romão et al., 2018; Hare et al., 2019.

Pancreas
↑ Cell cycle
↑ Functionalization Langerhans islets
↑ Insulin secretory capacity

Liver
↑ Cell cycle
↓ Branched chain amino acids
↓ Metabolism of xenobiotics
↓ Synthesis of lipids/lipoproteins

Bone marrow
↓ Cell cycle
↓ Inflammation
↑ Metabolism of lipids and lipoproteins
↑ Bone mass



Muscle
↑ Cell cycle
↑ Uptake/biosynthesis cholesterol
↓ Oxidative muscle phenotype

Fat
↑ Adipocyte differentiation
↑ Brown like adipocytes
↑ Oxidative metabolism
↓ Inflammation

Mammary gland
↑ Cell proliferation (epithelial cells)
↑ Triglyceride biosynthesis
↓ Apoptosis
↑ Metabolism

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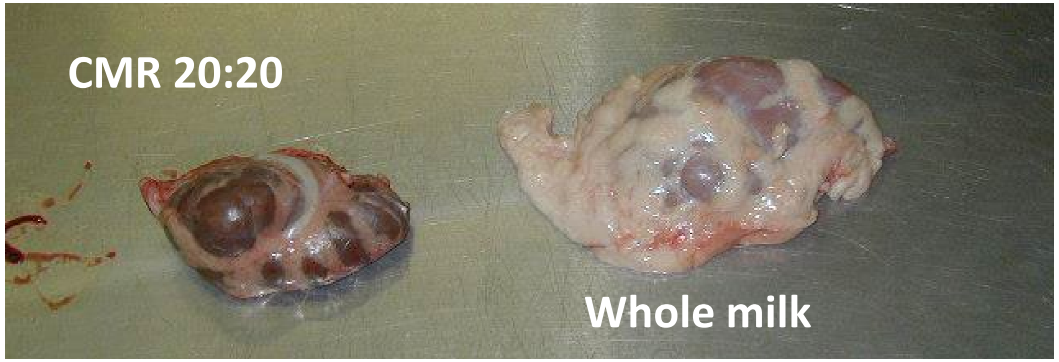
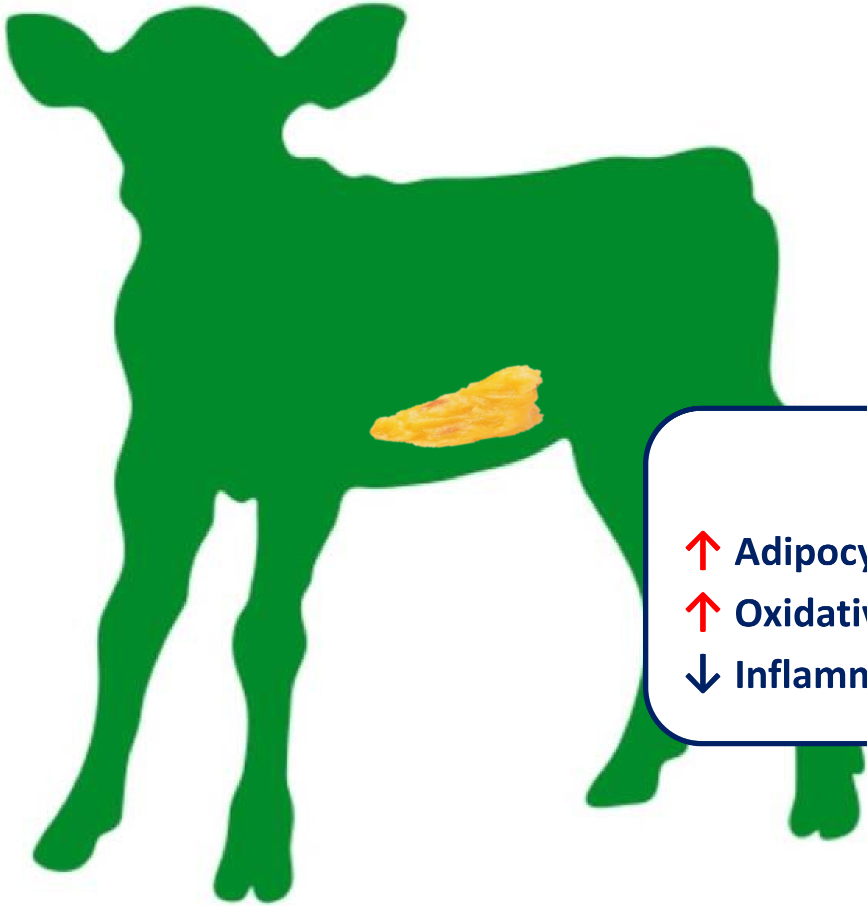
Trouw Nutrition R&D,
Leal et al., 2016, 2017, 2018; Romão et al., 2018; Hare et al., 2019.

Lean growth vs lipid distrophy



Van Amburgh, 2011



Fat

↑ Adipocyte differentiation
↑ Oxidative metabolism
↓ Inflammation

- Fat functionality
  - Immune competence
  - Thermoregulation
  - Energy homeostasis

Trouw Nutrition R&D,
Leal et al., 2016, 2017, 2018; Romão et al., 2018; Hare et al., 2019.

Longitudinal study at the Trouw Nutrition Dairy facility (NL)

2014 | 2015 | 2016 | 2017 | 2018 | 2019

Preweaning

Q1 2014 – Q3 2015

Heifer development

Q2 2014 – Q3 2017

1st Lactation

Q4 2015 – Q3 2018

2nd Lactation

Q1 2017 – ?? 2019

Conventional: 0.6 kg/d

LifeStart: 1.2 kg/d

Trouw Nutrition R&D. Leal et al., 2021

Preweaning plane on 1st and 2nd lactation

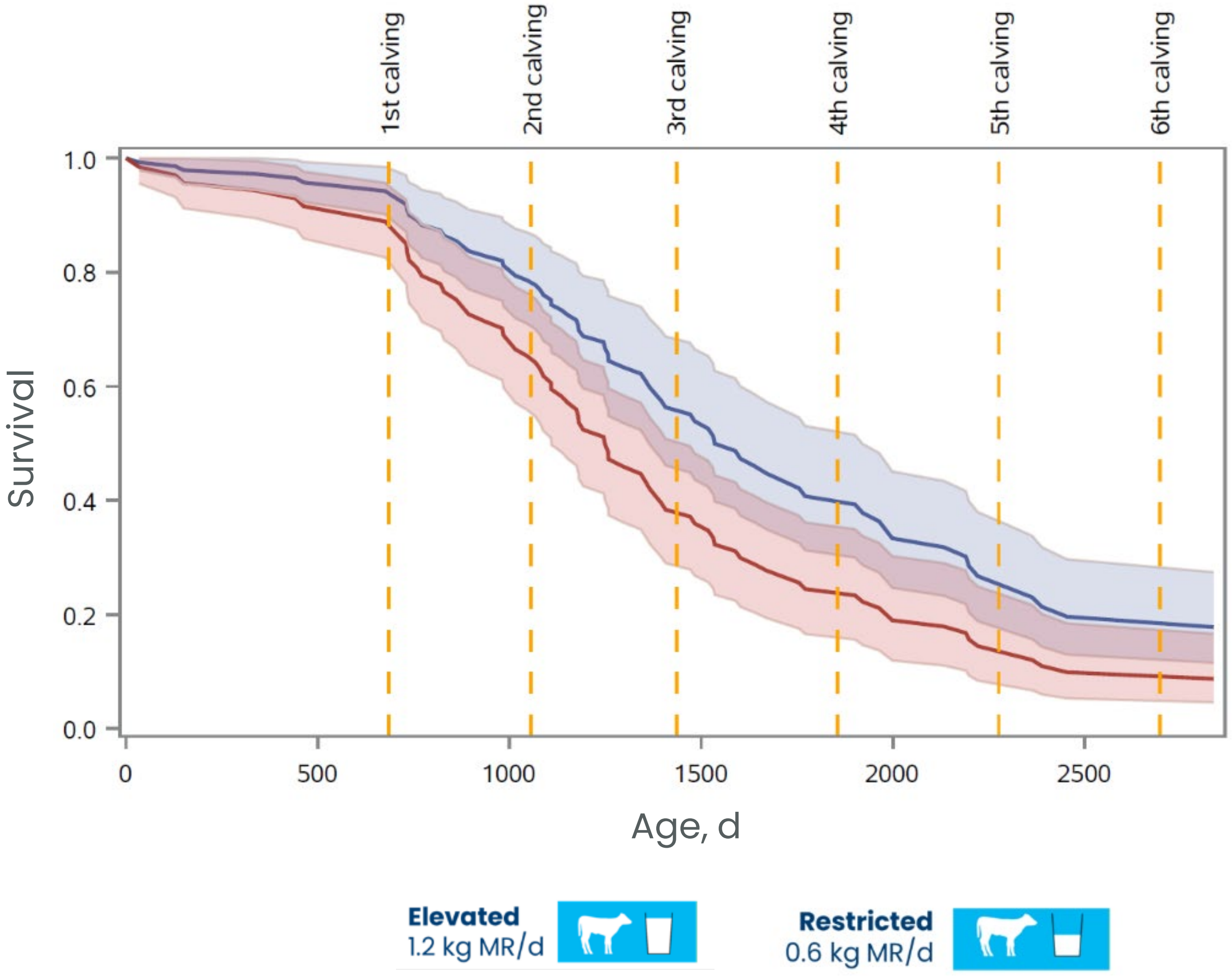
Item	Treatment		SEM	P-value	
	ELE	RES		Treat	Treat x WIM
First lactation (n=64 cows)					
Dry-matter intake, kg/d	19.7	19.0	0.2	**0.01**	0.62
Milk yield, kg/d	29.1	29.1	0.4	0.98	0.25
Fat-protein corrected milk, kg/d	30.8	29.9	0.2	**0.01**	0.91
Milk composition					
Fat, g/d	1296	1213	9	**<0.01**	0.87
Protein, g/d	995	996	10	0.95	0.73
Lactose, g/d	1363	1368	18	0.86	0.96
Body weight, kg	585	593	7	0.44	0.96
Body condition score, 1-5 scale	3.21	3.30	0.02	**<0.01**	0.46
Second lactation (n=45 cows)					
Dry-matter intake, kg/d	23.3	23.0	0.3	0.50	0.94
Milk yield, kg/d	34.7	33.3	0.7	0.23	0.12
Fat-protein corrected milk, kg/d	36.8	35.5	0.5	0.12	0.38
Milk composition					
Fat, g/d	1536	1464	22	**0.04**	0.73
Protein, g/d	1208	1184	16	0.33	**0.05**
Lactose, g/d	1593	1545	32	0.35	0.23
Body weight, kg	649	665	8	0.20	1.00
Body condition score, 1-5 scale	3.04	3.17	0.04	0.08	0.68

Elevated
1.2 kg MR/d

Restricted
0.6 kg MR/d

Trouw Nutrition R&D. Leal et al. under review

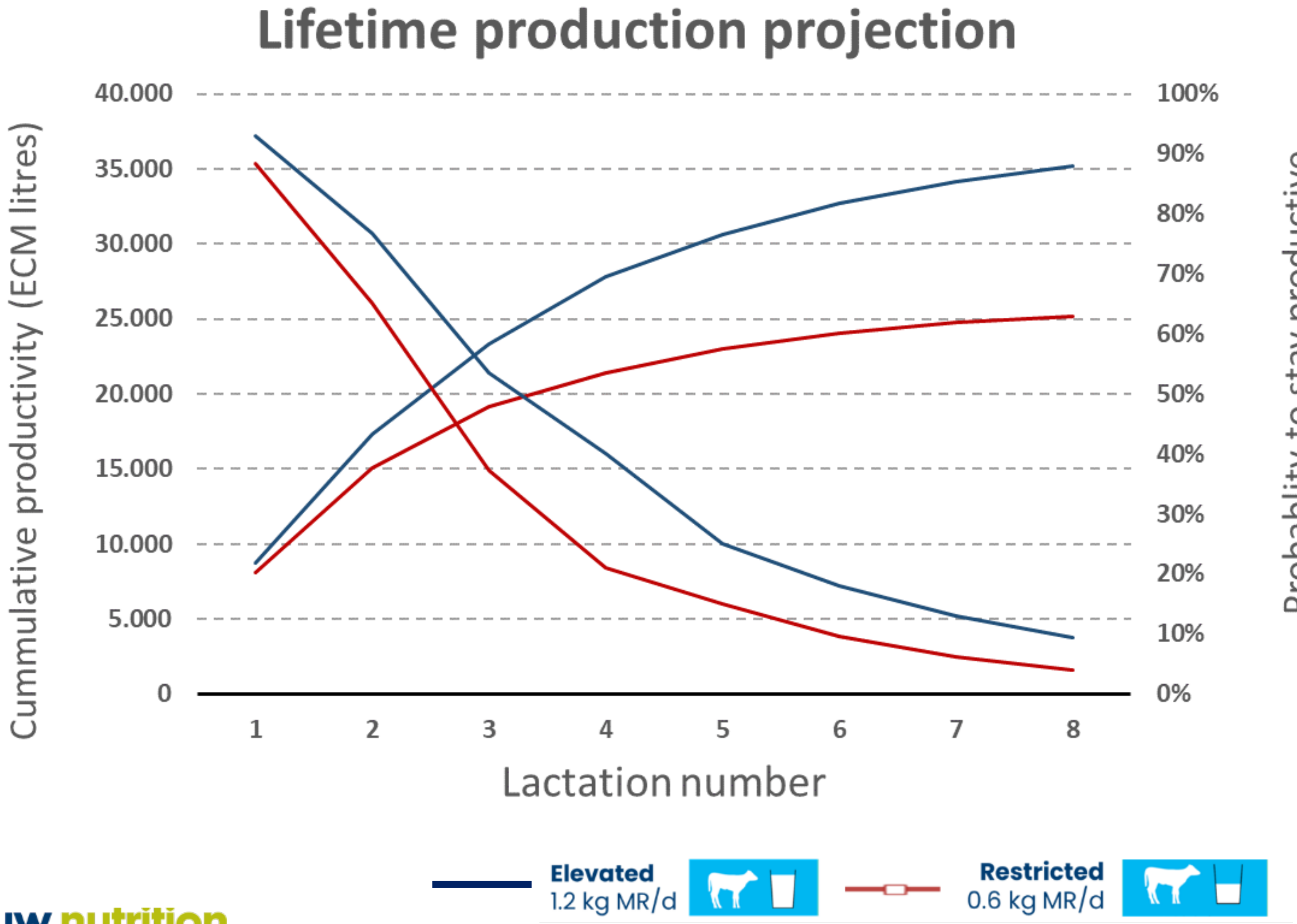
Preweaning plane on survival



Item	Treatment ELE (n = 43)	Treatment RES (n = 43)	*P-value*
Survival 1st calving			
% of total (n calving)	93% (40)	88% (38)	0.36
Survival 2nd calving			
% of total (n calving)	77% (33)	65% (28)	0.07
Survival 3rd calving			
% of total (n calving)	54% (23)	37% (16)	0.05
Survival 4th calving			
% of total (n calving)	42% (18)	23% (10)	0.02
Survival 5th calving			
% of total (n calving)	26% (11)	14% (6)	0.02
Survival 6th calving			
% of total (n calving)	21% (9)	7% (3)	0.02
Survival August 2023			
% of total (n calving)	21% (9)	5% (2)	0.02

Trouw Nutrition R&D. Leal et al. under review

Cumulative production corrected by culling

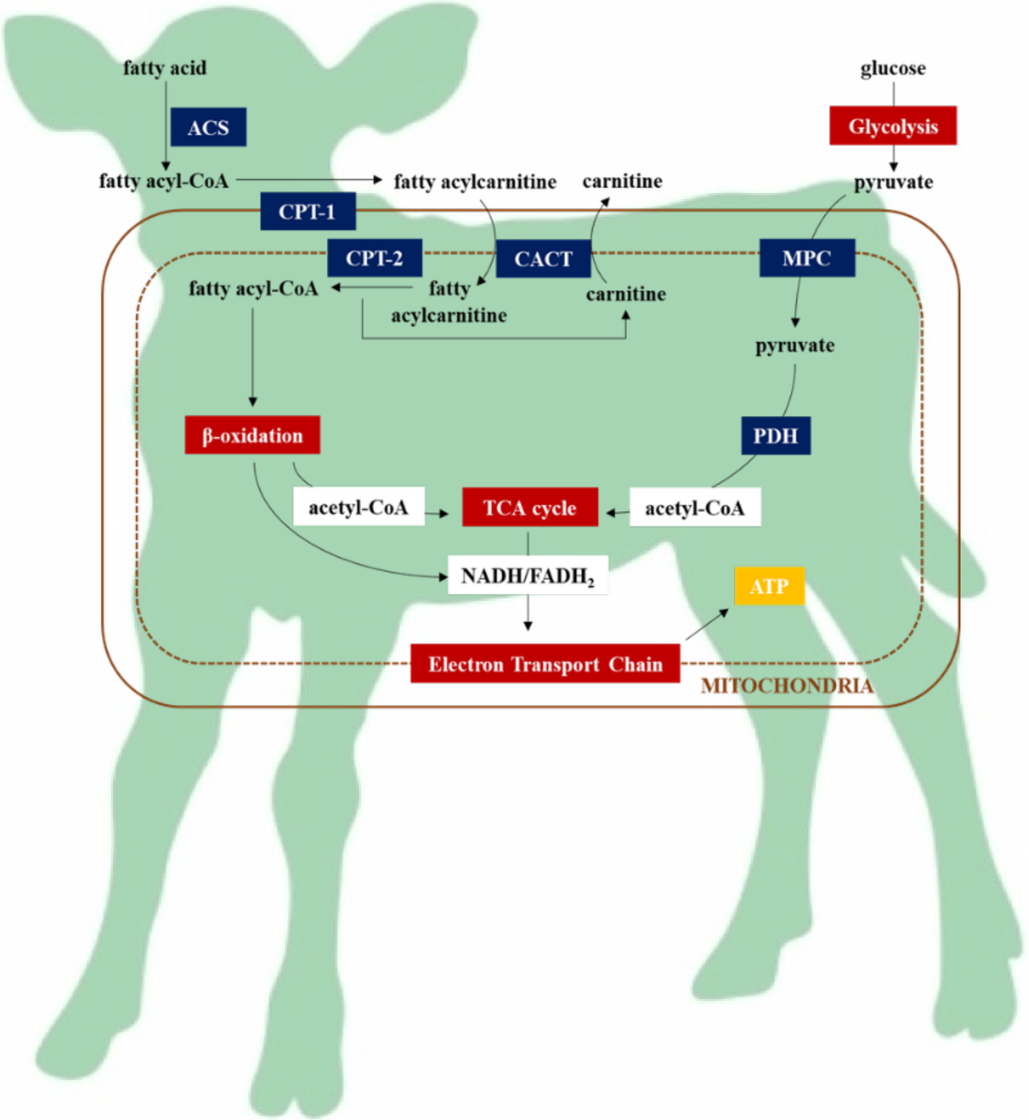


35.000 l in 3.3 lactations
10,600l/lactation
vs
25.000l in 2.5 lactations
10,000/lactation

- More milk to sell
- Fewer heifers to raise

Energy metabolism of the calf

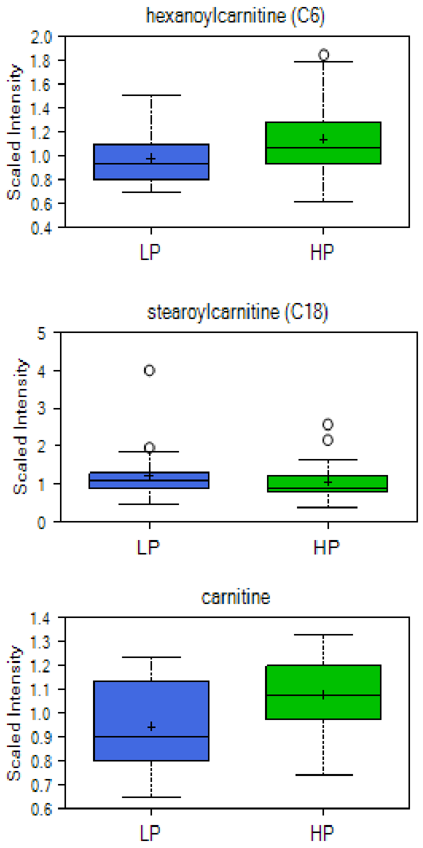
	Biochemical	ELE d2 vs. RES d2	ELE d49 vs. RES d49
Fatty Acid Metabolism	butyrylcarnitine	1.14	0.89
	butyrylglycine	1.08	0.42
	propionylcarnitine	1.06	0.57
	propionylglycine	1.02	0.24
	valerylglycine	0.97	0.14
	hexanoylglycine	0.97	0.70
	N-palmitoylglycine	1.06	1.10
	acetylcarnitine	1.10	1.28
	3-hydroxybutyrylcarnitine	1.14	1.16
	hexanoylcarnitine	1.13	1.22
	octanoylcarnitine	1.05	1.41
	decanoylcarnitine	1.06	1.49
	laurylcarnitine	1.01	1.37
	myristoylcarnitine	1.06	1.25
	palmitoylcarnitine	1.07	1.61
	palmitoleoylcarnitine	1.05	1.24
	stearoylcarnitine	1.08	1.23
	linoleoylcarnitine	0.90	1.29
	oleoylcarnitine	1.05	1.26
	myristoleoylcarnitine	1.14	1.52
	suberoylcarnitine	0.83	0.94
	adipoylcarnitine	0.89	1.18
	carnitine	1.04	1.20
	3-hydroxybutyrate (BHBA)	1.09	0.39
TCA Cycle	citrate	0.95	0.80
	aconitate [cis or trans]	0.92	0.86
	isocitrate	0.98	0.91
	alpha-ketoglutarate	1.08	0.91
	succinylcarnitine	0.98	1.27
	succinate	1.08	0.85
	fumarate	1.09	0.83
	malate	1.11	0.79
	tricarballylate	0.83	0.12
	2-methylcitrate/homocitrate	0.94	0.62



Trouw Nutrition R&D. Leal et al., 2021

Increased β-oxidation capacity in LifeStart heifers

Pathway	Biochemical	HP / LP
Fatty Acid Metabolism (Acylcarnitine)	acetylcarnitine (C2)	1.12
	3-hydroxybutyrylcarnitine (1)	1.09
	3-hydroxybutyrylcarnitine (2)	1.03
	hexanoylcarnitine (C6)	1.17
	octanoylcarnitine (C8)	1.16
	decanoylcarnitine (C10)	0.97
	cis-4-decenoylcarnitine (C10:1)	0.99
	laurylcarnitine (C12)	0.82
	myristoylcarnitine (C14)	0.97
	palmitoylcarnitine (C16)	0.88
	stearoylcarnitine (C18)	0.87
	oleoylcarnitine (C18:1)	0.88
	myristoleoylcarnitine (C14:1)*	0.84
	suberoylcarnitine (C8-DC)	0.81
	adipoylcarnitine (C6-DC)	0.97
Carnitine Metabolism	deoxycarnitine	1.07
	carnitine	1.14



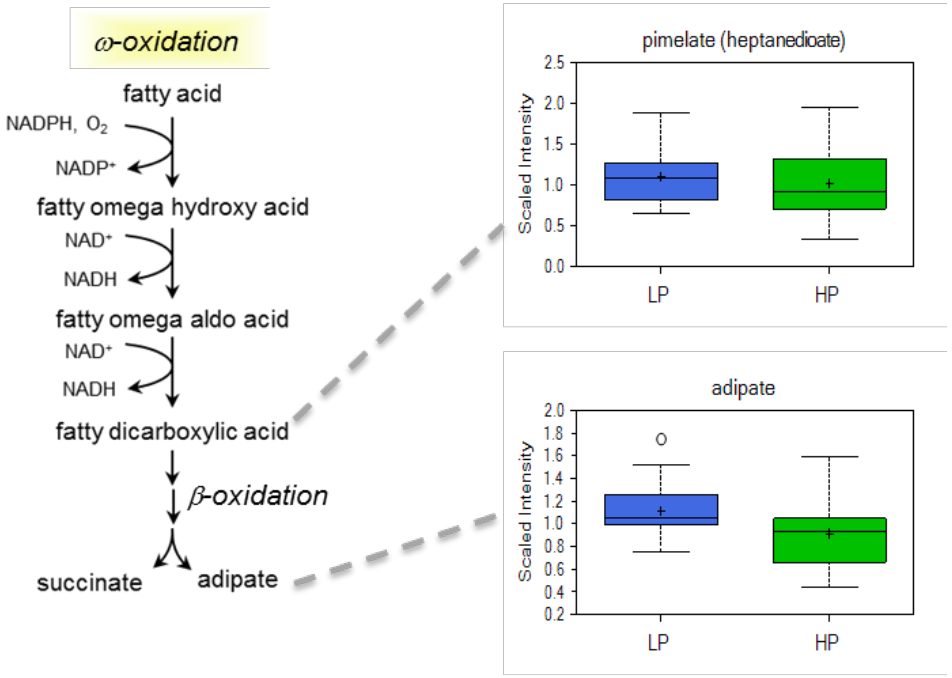
- **β-oxidation is key for energy production (Krebs cycle)**
- **Increased capacity for β-oxidation in LS heifers**
  - higher carnitine
  - lower long chain acylcarnitines
  - Increase in short and medium chain acylcarnitines

trouw nutrition
a Nutreco company

Trouw Nutrition R&D. Leal et al. under review

Reduced ω-oxidation in Enhanced heifers

Biochemical	HP / LP
dimethylmalonic acid	0.87
3-methylglutarate/2-methylglutarate	0.89
2-hydroxyglutarate	0.88
adipate	0.82
3-carboxyadipate	0.85
2-hydroxyadipate	0.9
3-methyladipate	0.92
maleate	0.9
pimelate (heptanedioate)	0.92
suberate (octanedioate)	0.95
azelate (nonanedioate)	0.98
sebacate (decanedioate)	0.99
undecanedioate	0.97
dodecanedioate	0.94
hexadecanedioate	0.96
octadecanedioate	0.98
eicosanodioate	0.91
docosadioate	0.94



- **Fatty acids can be also oxidized through ω−oxidation**
- **Occurs mainly**
  - mitochondria are overwhelmed
  - β−oxidation is impaired
- **Lower ω−oxidation in ENH heifers**
  - low adipate and other dicarboxylic fatty acids

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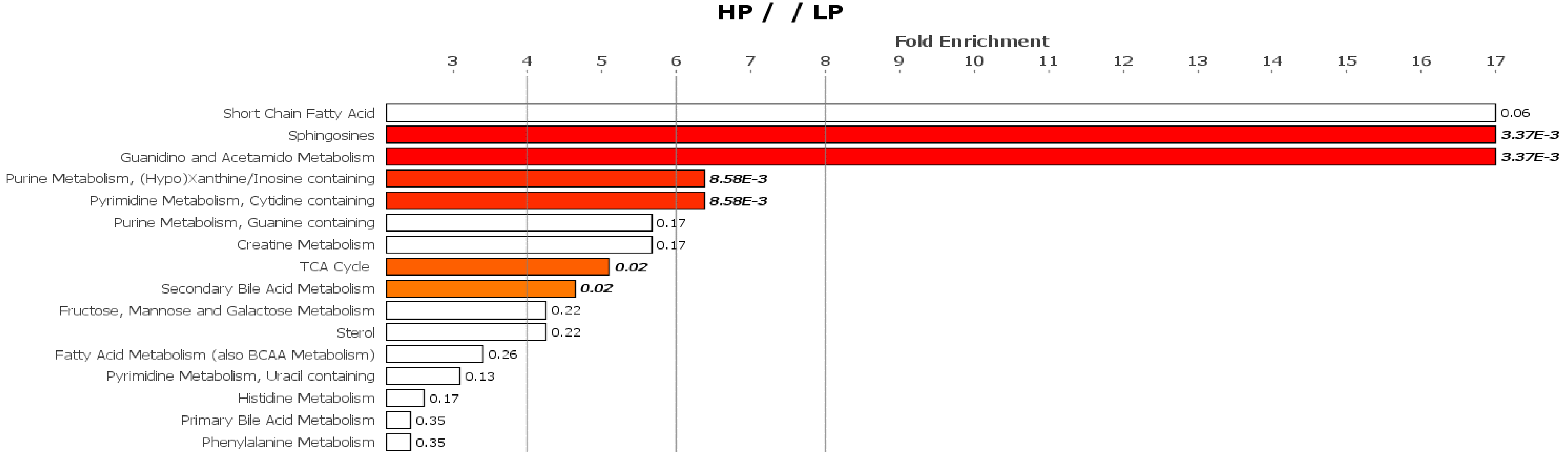
Trouw Nutrition R&D. Leal et al. under review

Different metabotypes at 60 DIM....



…adaptations are still present in 1st lactation (metabolic programming)…

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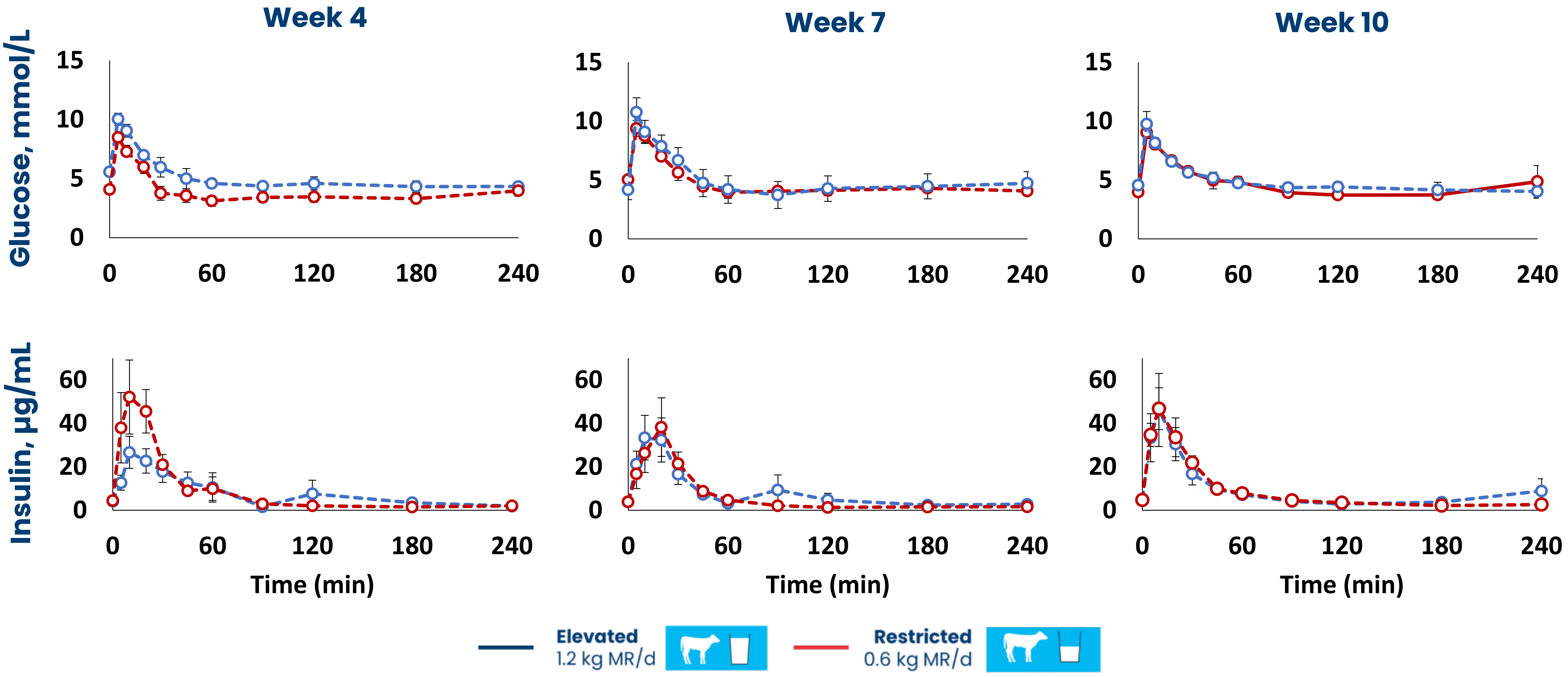
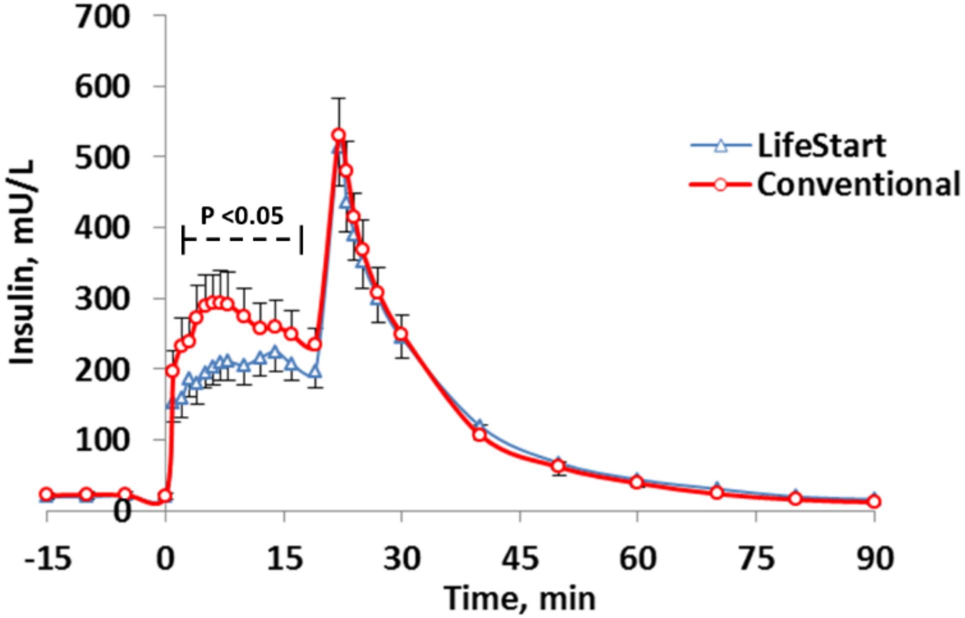
Trouw Nutrition R&D. Leal et al. under review

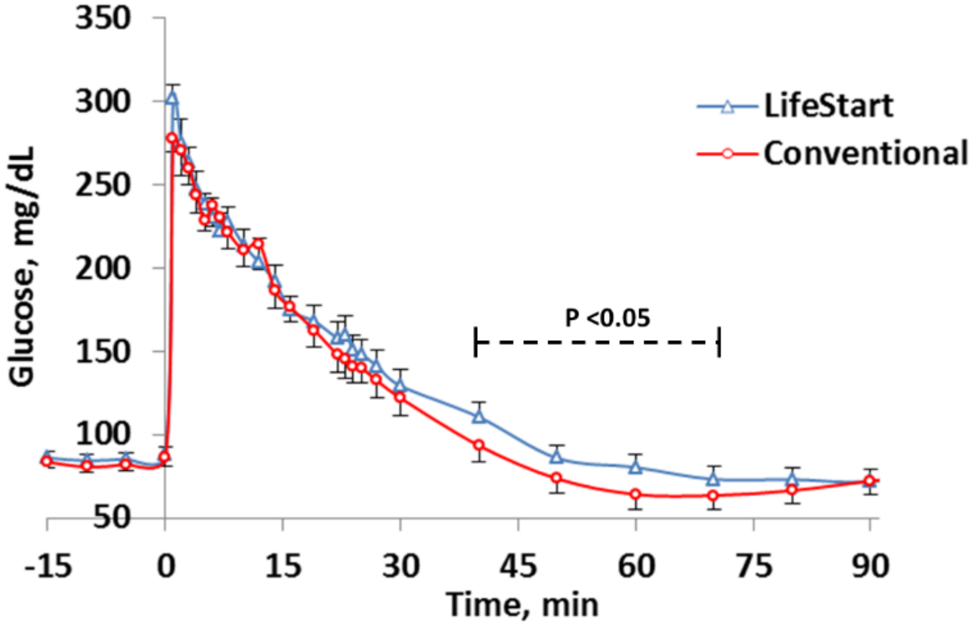
No effect on glucose tolerance at wk 4, 7 or 10



Trouw Nutrition R&D. MacPherson et al., 2016

Glucose response heifers





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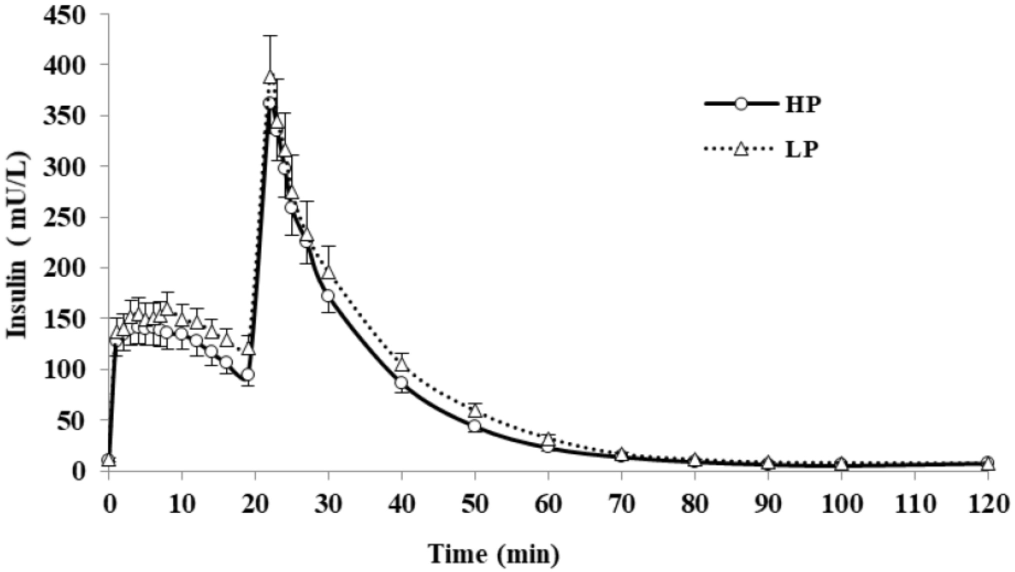
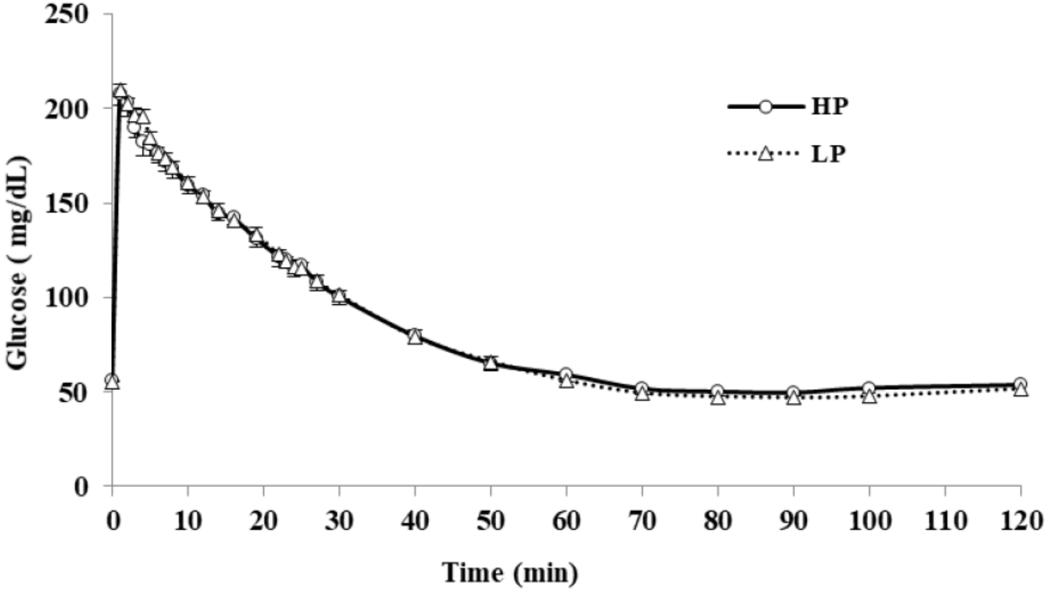
Glucose response cows (lactation)





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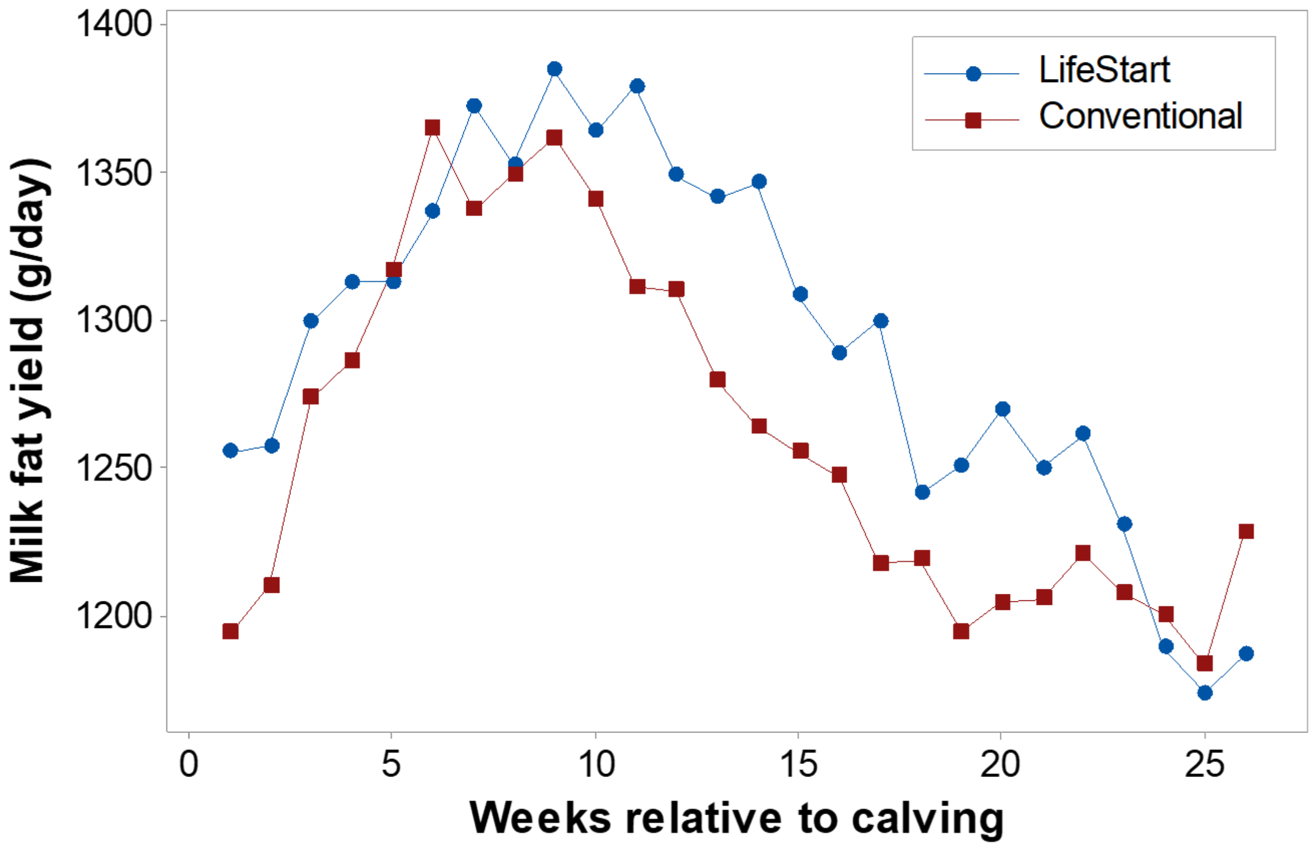
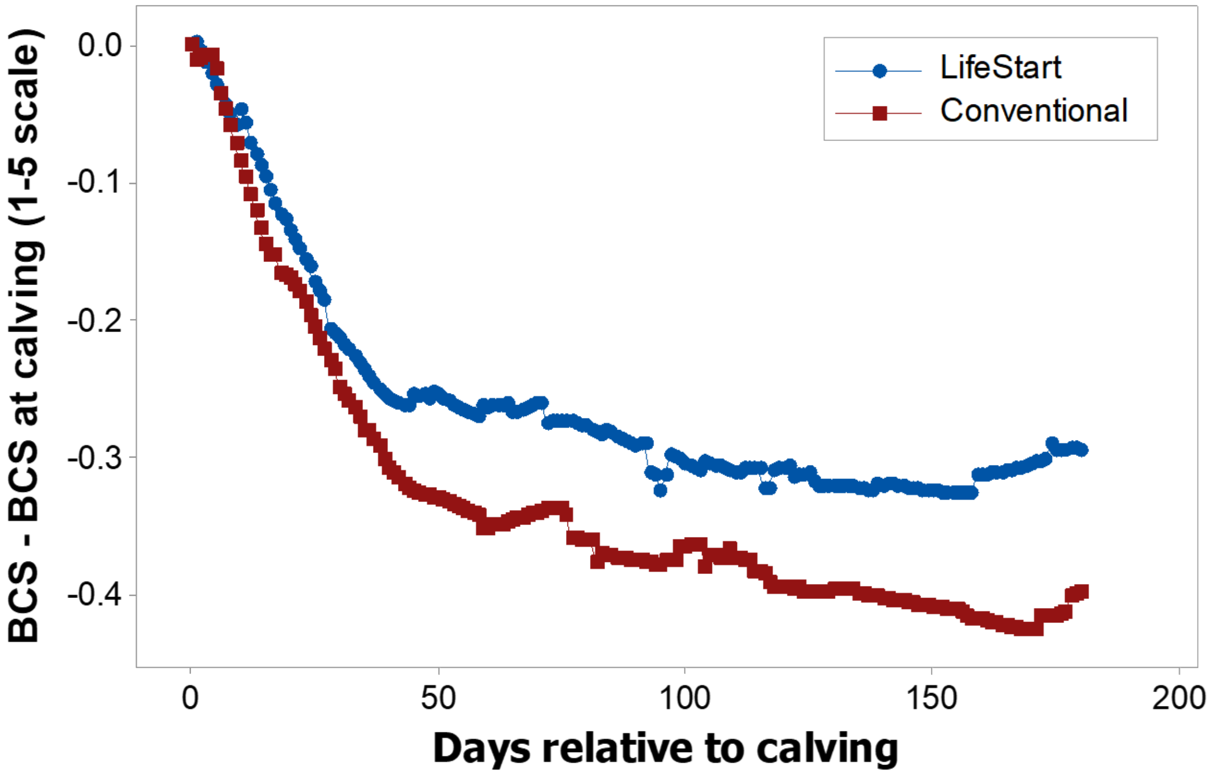
Phenotypically, milk fat yield is higher



However…

Change in body condition score is also higher



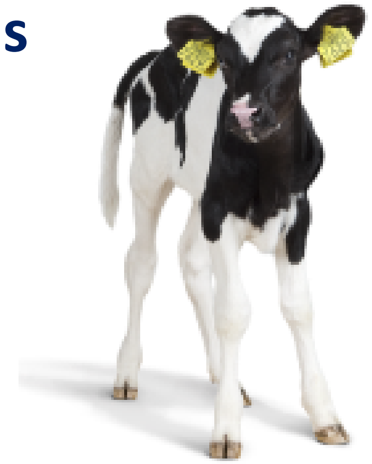
… so not at the expense of body reserves…

Conclusions from calf phase

- **Clear dietary differences between the 2 treatments at d49**
  - >45% of all metabolites

- **Metabolic pathways are affected by the total amount of nutrients supplied and by the nature of the diet**
  - ketogenic vs. glucogenic

- **Dietary interventions can lead to profound metabolic adaptations**
  - energy metabolism
  - organ development
  - microbiome



BIG CALF vs. SMALL CALF

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Conclusions from heifer phase

- **Differences in age at 1st AI can be explained by BW**
- **LifeStart heifers got pregnant earlier than Conventional heifers**
- **Preweaning feeding may have an effect on glucose/insulin metabolism at 12 months (FSIGTT)**
- **Metabolomics indicate that pre-weaning plane of nutrition can have carry over effects**
  - energy metabolism (β-oxidation vs. ω-oxidation)
  - amino acid metabolism
  - microbial fermentation end-products

Conclusions from lactation

- **Metabolism**
  - Energy metabolism
  - Microbially derived metabolites
  - Protein metabolism
  - Insulin/glucose metabolism
- **Breeding**
  - Earlier 1st AI
  - Earlier pregnancy
  - Earlier 1st calving
- **Lactation (until 180 DIM)**
  - Greater fat yield and FCM
  - Lower BCS mobilization
  - Improved survival

Traditional

Intake 10% BW

ADG 500-600 g/d

LIFESTART®

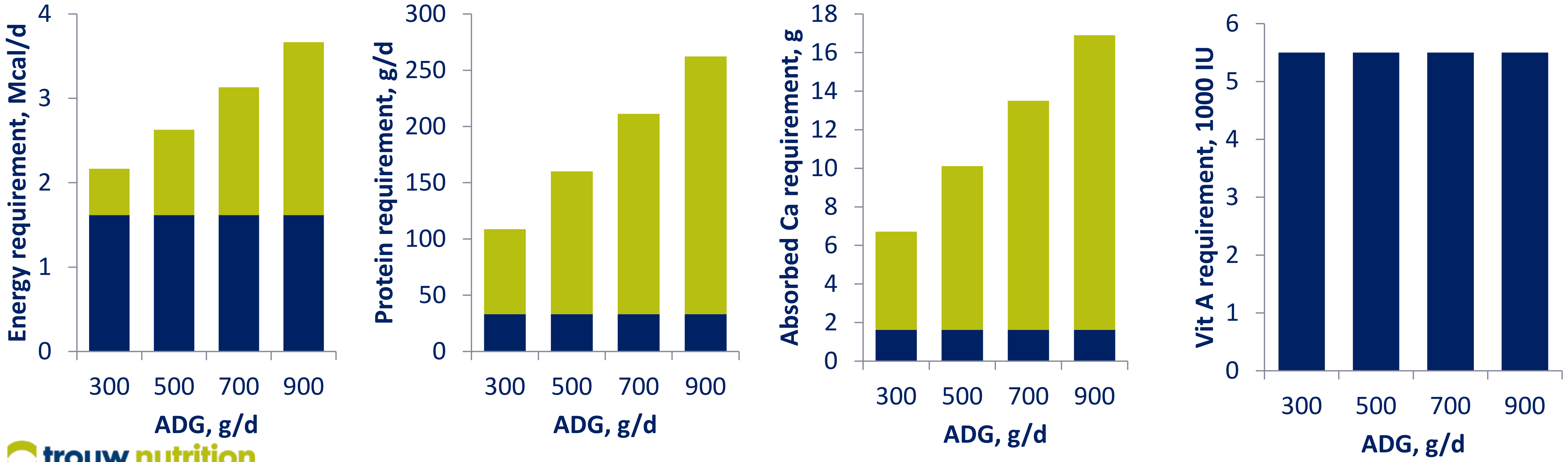
SETS LIFE PERFORMANCE

Intake 20% BW

ADG 800-1000 g/d

■ Growth

■ Maintenance



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Adapted from NRC, 2001

Restoring nutrient supply and signaling

Biological reference

2015 → 2023

Increasing the fat inclusion

- Increased survival in preweaning phase
- Improvements of fecal scores / therapeutical treatments
- Hormonal homeostasis (insulin-glucose metabolism)

Fat sources in milk replacer

- Possible to formulate based on FA profile
- High PUFA negative for calves
- Inclusion of dairy cream largely beneficial

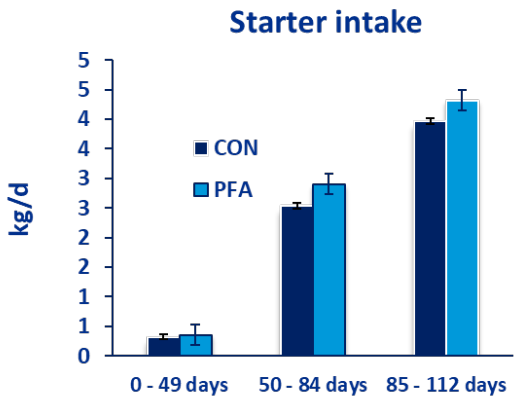
Balancing FA

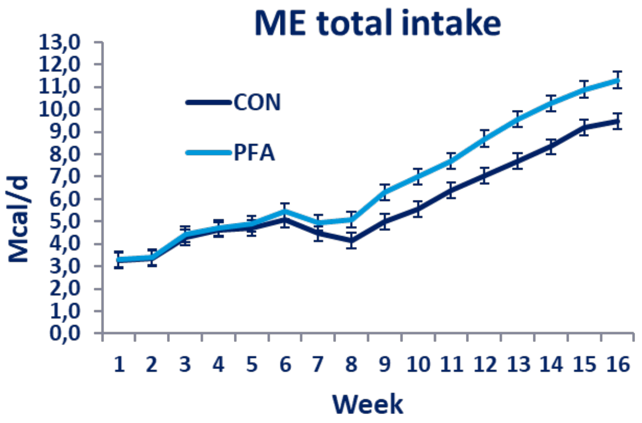
- Improvement in fat digestibility and fecal scores
- Increased MR and starter intakes → increased performance
- Enhanced rumen papillae / ileum villi development

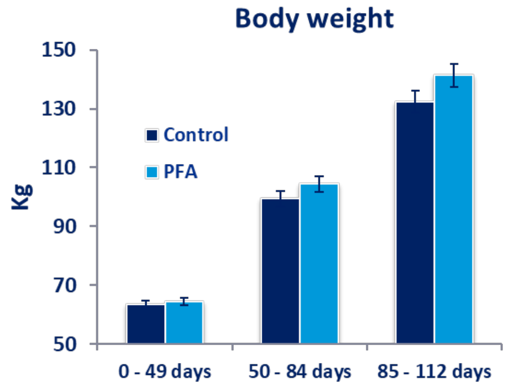
Wilms, J. Trouw Nutrition R&D

Restoring early weaning nutrient shortages

Adding fat to starters without compromising rumen development and function results in greater energy intake and growth







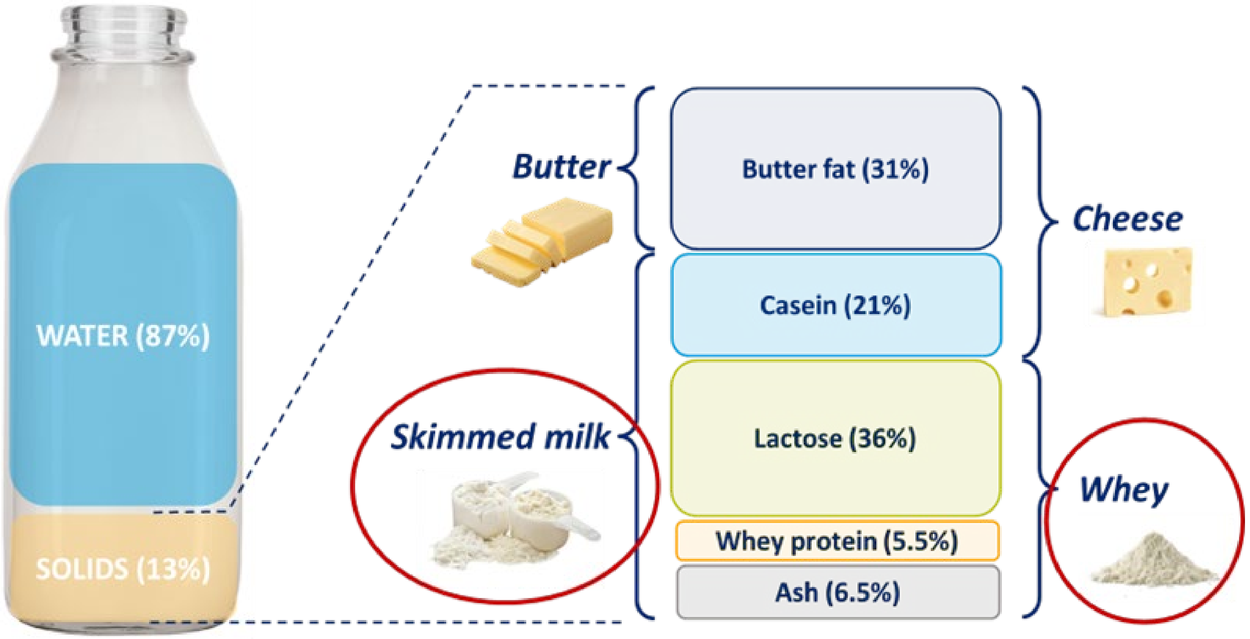
Biological reference

trouw nutrition
a Nutreco company

Trouw Nutrition R&D, Amado et al., 2022

Restoring milk quality

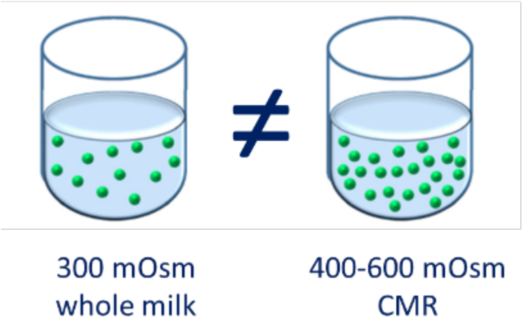
When replacing milk…
…nothing can be left to chance…

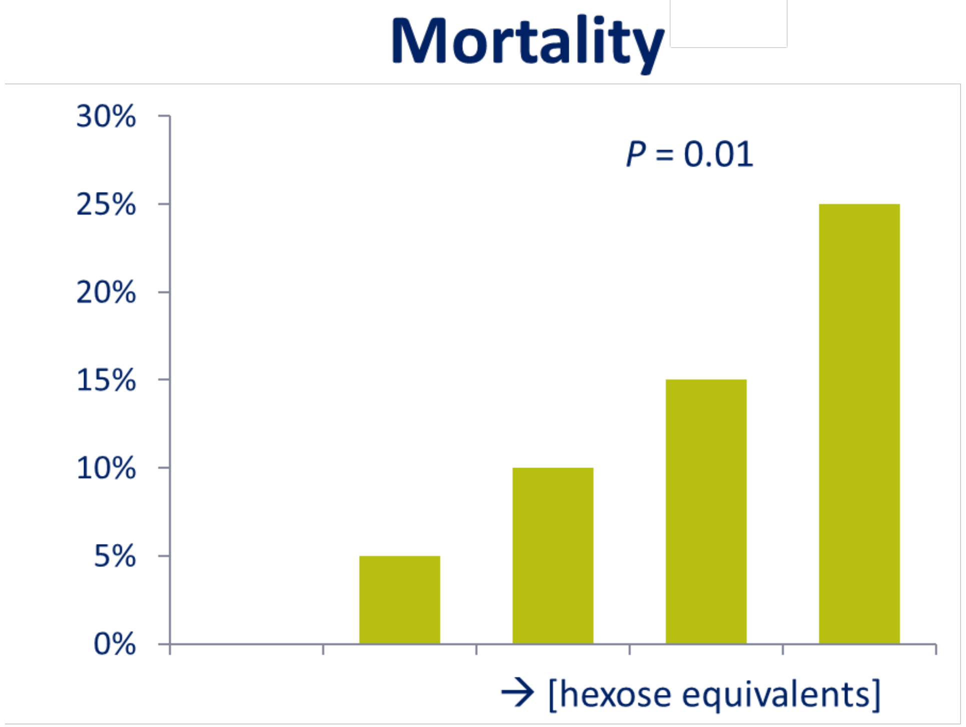


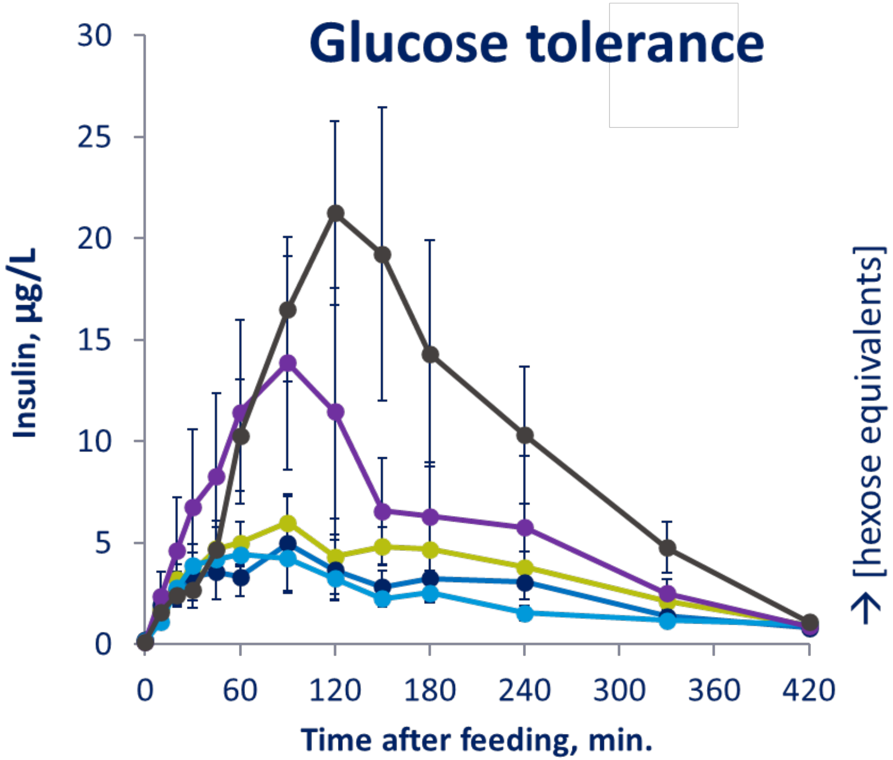
Wilms, J. Trouw Nutrition R&D

- Water
- Physicochemical composition
- Carbohydrate fraction
- Fat fraction
- Protein fraction
- Functional components
- Minerals
- Vitamins

Osmolality as an example







Trouw Nutrition R&D. Wilms et al. 2020

Replacing milk is an exercise of nutrition and circularity

NUTRITION

Suckling from dam

Pasteurized whole milk

Skim milk high fat CMR

Skim milk low fat CMR

Whey based CMR

Vegetable protein CMR

Oil seed liquid feeding

CIRCULARITY

250 liters?

500 liters?

Even more?

LifeStart “restoration” ladder

Weaning age

Post weaning nutrient supply

Micro CMR composition

Macro CMR composition

Feeding plane | Ad lib feeding

Colostrum | Transition milk

New value, new values, new objectives, new solutions

LIFESTART
SETS LIFE PERFORMANCE

OLD OBJECTIVES

- Growth
  Feed conversion
- Preweaning mortality
- Solid feed intake
  Early weaning
- Lean growth
  Rumen development
- Fecal scores
  Antibiotic treatments

NEW OBJECTIVES

- Calf development and health
- Metabolic resilience
- GIT development
  Gut barrier function
- Lifetime health
- Lifetime productivity

ADDITIONAL BENEFITS

- Resource efficiency and circularity
- Animal welfare
- Reduced carbon intensity
- Meeting societal expectations

Take home messages

- “LifeStart” is a true case of metabolic programming
- Restoring perinatal environment restores phenotypical potential
- Milk does not only transfer nutrients, but also imprinting signals
- Improving perinatal environment, is the single greatest opportunity to improve dairy productivity, efficiency, health, and sustainability


OUR PURPOSE
Feeding
the Future
Thank you!