Preweaning milk allowance effects on long-term metabolism in Holstein heifers and cows

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The impact of preweaned calf weight gain on first and later lactation performance was clearly established by a report from Soberon et al. 2012 (Kertz 2019 p. 153-157). This was mainly attributed to mammary gland development (Soberon and Van Amburgh 2007). Another possible factor was explored by Leal et al., 2025a. They hypothesized that "an increased preweaning nutrient supply would have a long-lasting impact on metabolism that may contribute to explain improved milk productivity reported in previous study".

"This study was conducted at the Trouw Nutrition Dairy Research Facility in the Netherlands. The calf phase of development of the participating heifers was previously reported by Leal et al. (2021) which described the main metabolic adaptations of neonatal calves fed an elevated plane of nutrition. Eighty-six female Holstein calves, born from a single herd of about 120 dairy cows, were blocked at birth in pairs by birth sequence and parity of dam (primiparous or multiparous). Calves in the same block received an equal colostrum supply of 4 L of pasteurized colostrum that had been frozen within 6 h after birth. The colostrum was previously prepared by pooling colostrum from different dams and preparing colostrum doses that were equal in quality (≥22% Brix), composition, and protocol of supply. "

"Within block, calves were randomly allocated to one of 2 treatments: 5.41 Mcal of ME in 8 L of MR/day (1,200 g/day) for an elevated level of nutrient intake (ELE; n = 43), or 2.71 Mcal of ME in 4 L of MR/d (600 g/d of MR powder) for a restricted level of nutrient intake (RES; n = 43). Calves were fed MR (150 g/L; 24% CP, 18% crude fat, and 45% lactose) twice daily via nipple buckets. Calves had ad libitum access to water, calf starter (17.3% CP, 24.4% NDF, 2.0% crude fat, and 18.2% starch; 3-mm pellet), and wheat straw (3-cm chop length)."

"All calves were gradually weaned by reducing the amount of MR in each meal by 50% starting in week 7 and ending the weaning process by week 8. After weaning, calves were kept for 2 more weeks in their individual pens. Only 85 calves were used in this study."

"From wk 10, heifer calves from both treatments were commingled in pens of 4 to 6 and managed in the same way. The pens were created based on animal age so that all animals would go through the same pens. Thus, no randomization of animals to pens were required. From 10 weeks until 4 months of age, heifers were allowed ad libitum access to calf starter and a grower TMR (see **Table 1** for composition). From 4 months until breeding age, heifers received the grower TMR exclusively. Whereas individual BW was recorded weekly until 10 weeks of age, thereafter the frequency was reduced to every second month until the close-up period."

"Heifers became eligible for breeding once their BW was above 390 kg. If heifers exhibited signs of estrus, they were bred by artificial insemination with conventional semen. Breeding decisions were made by technicians strictly blind to the treatments. Heifers were examined for pregnancy by rectal palpation 35 to 45 days after insemination unless the heifer was observed in estrus before this time. Heifers were allowed 3 services to conceive before being eliminated from the study."

Methodology and the Insulin-Modified Intravenous Glucose Tolerance Test are described in the text as well as blood sampling and analyses.

Table 1. Ingredient and estimated nutrient composition of rations.

	Grower	Postbreeding
Ingredients, %		
Grass silage	20.3	80.1
Corn silage	44.2	---
Grass hay	5.3	---
Wheat straw	---	12.4
Brewers grain	6.0	---
Rapeseed meal	---	6.3
Vitamin mineral premix	---	1.2
Concentrate	24.2	---
Nutrients, % of DM		
CP	15.9	14.4
Ether extract	4.1	3.5
Crude fiber	17.0	24.5
NDF	17.1	47.4
Starch	20.4	6.1
Sugar	4.1	3.4

- With grass silage, grass hay, and 12.4% wheat straw for the postbreeding TMR, these rations are not typical for the US. But given the climate and conditions, this is not unusual for the Netherlands.
- The postbreeding TMR was lower in CP than the grower ration, but much lower in NDF and higher in starch than the grower ration.

Table 2. Effect of preweaned milk replacer (MR) on growth, breeding, and conception parameters.

	Control	>MR fed	SEM	*P* <
Heifer grower				
Heifers, n =	42	43		
Body weight, day 70, lb	186.8	206.8	2.66	<0.001
Body weight, day 330, lb	785.5	800.9	10.42	0.30
Daily gain, day 70-330, kg	2.29	2.27	0.04	0.71
Breeding				
Heifers, n =	40	41		
Body weight 1st service, lb	909.2	916.3	12.1	0.58
Daily gain day 70 1st service, lb	2.20	2.20	0.04	0.71
Age 1st service, day	399	395	6.1	0.25
1st service conception rate, %	63	63	7.4	0.30
Conception				
Heifers, n =	38	40		
Age at conception, days	422	412	8.4	0.19
Services per conception, n	1.46	1.35	0.11	0.48

- Body weight at 70 days of age was greater for calves fed more milk replacer before weaning (Leal et al., 2021),
- Body weight at 330 days of age did not differ for heifers which had been fed more milk replacer before weaning. This is similar to many studies in which preweaning body weight gain did not continue later as heifers. However, this does not mean there are no benefits for preweaning weight gain differences as metabolic and mammary gland benefits may accrue. And early growth epigenetic differences may also be turned on.
- There were no treatment differences in breeding and conception.
- However, there were not many heifers per treatment and these numbers decreased with age. And variability (SEM) generally increased with age making heifer studies challenging to do with more heifers per treatment (Kertz and Chester-Jones 2004).

Figure 1. Plasma glucose and insulin concentrations during an insulin-modified intravenous glucose tolerance test on d 370 of life in dairy heifers (n = 20) fed a restricted (RES, red) or elevated (ELE, blue) level of nutrient intake preweaning. Data points are mean ± SE. *P < 0.05; †0.05 ≤ P < 0.10.

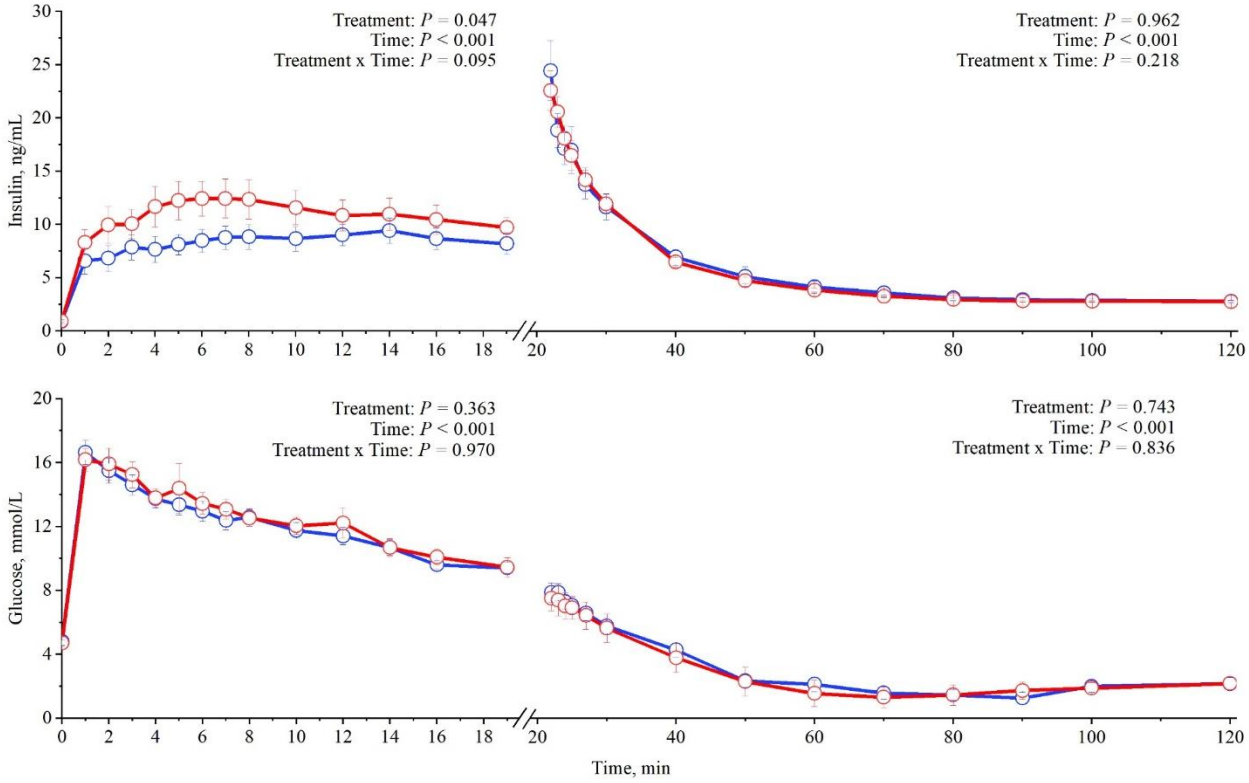

Figure 1 (kindly provided by Dr. Jean-Batiste Daniel) shows that insulin was greater for calves fed more milk replacer up to about 10 weeks at weaning, but that difference gradually decreased with age. That is not unexpected as ruminal fermentation develops with volatile fatty acid production. This results in less glucose not escaping ruminal fermentation and liver production of glucose from propionate resulting from propionic acid absorbed into the blood from rumen production. Insulin sensitivity was less ($P < 0.02$) in heifers which had been fed less milk replacer as calves.

The metabolites assayed showed a number of significant differences, but their role and significance are not known at this time.

A subsequent publication (Leal et al., 2025b) followed these heifers into their first two lactations **(Table 3**).

Table 3. Intake, milk production, body weight and condition, and survival by lactations.

	Control	**>MR fed**	**SEM**	***P* <**
First lactation, lb/day (n = 78)	38	40		
Dry matter intake	41.0	42.5	0.37	< 0.01
Fat/protein corrected milk	65.0	66.1	0.59	0.21
Body weight, lb	1310	1293	11.5	0.24
Body condition score, 1-5	3.30	3.22	0.02	<0.01
Second lactation, lb/day (n = 61)	28	33		
Dry matter intake	48.9	50.4	0.66	0.16
Fat/protein corrected milk	73.5	78.4	1.12	0.03
Body weight, lb	1458	1429	15,0	0.22
Body condition score, 1-5	3.14	3.05	0.04	0.10
Third lactation n =	16	23		
Fourth lactation n =	10	18		
Fifth lactation, n =	6	11		

- While cow numbers per treatment were limited, survival by lactation was always better for cows fed more MR as calves. Culling reasons were for cows fed more MR as calves; and were in order most for mastitis (8 vs 10), fertility (9 vs 8), infectious disease leading to death or euthanasia (6 vs 6), lameness (2 vs 1), and udder morphology (1 vs 3).
- Total dry matter intake was greater for cows fed more MR as calves.
- Fat and protein corrected milk did not differ in first lactation but was greater in second lactation for cows fed more MR as calves.
- Body weights did not differ but authors speculated that lower body condition scores for those cows fed more MR as calves could be due to preweaning nutrition may have long-term effects on body composition and energy partitioning, And that cows with better nutritional status in early lactation might prioritize milk production, leading to increased mobilization of body reserves and a subsequent decline in body condition.

The Bottom Line

Preweaned dairy calf weight gain differences impact first and subsequent lactation milk production. In this study, weight gain differences preweaning did not continue, and did not result in breeding and conception differences either. But the mechanism (s) by which lactation benefits from preweaned weight gain differences is not yet understood. Subsequent milk production and survival were greater into the 5th lactation for cows which were fed more MR as calves. A major challenge is doing studies with enough calves and heifers per treatment to better detect subsequent statistically and biologically significant differences.

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