Maternal nutrition carry-over effects on beef cow colostrum but not on milk fatty acid composition

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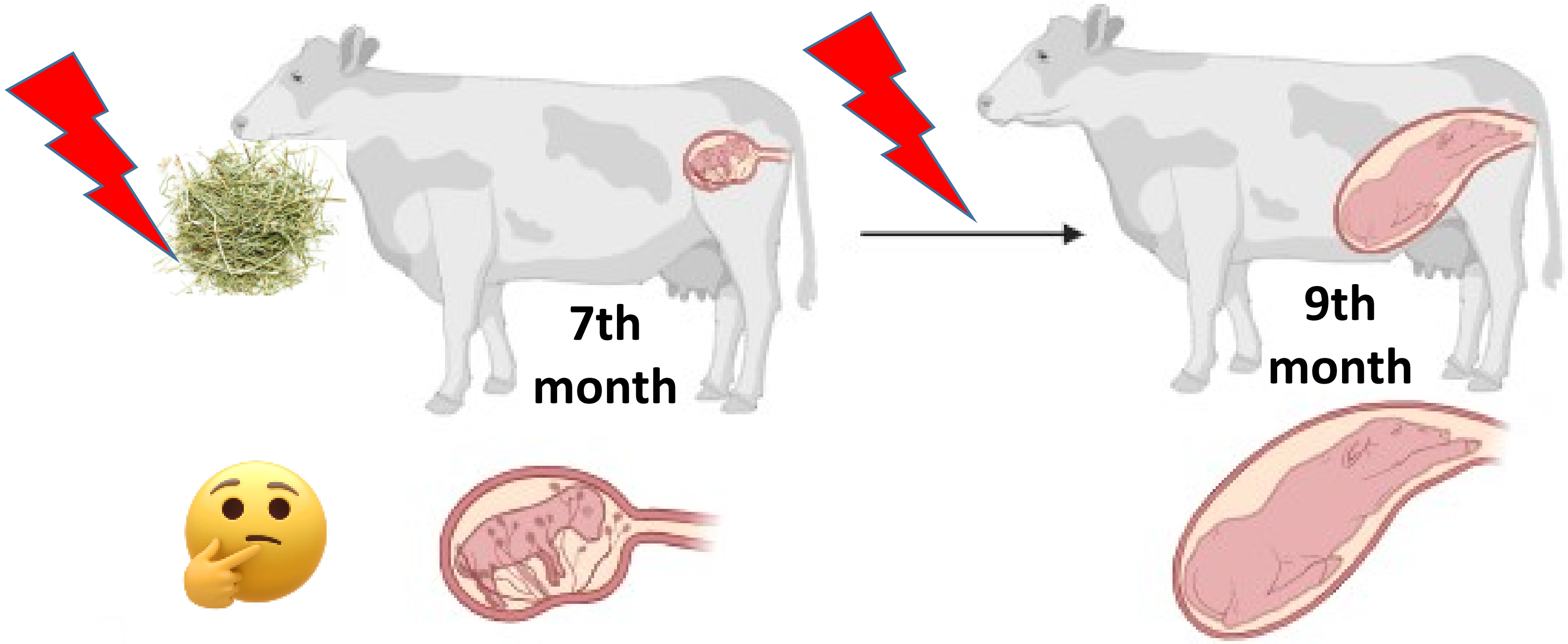
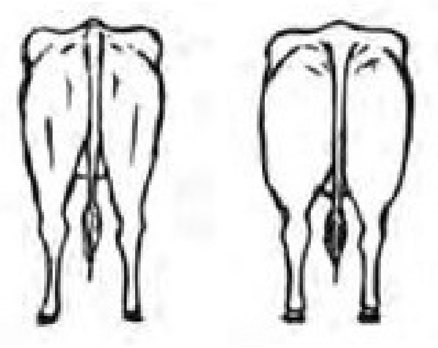
Introduction

Beef cows undernourished the **last trimester of pregnancy** as a result of **low feed resources → carry-over effects** on the **cow-calf pairs**?



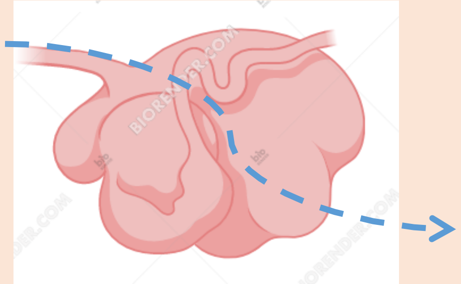
- ↑ **Metabolic disfunction?**
- ↑ **Inflammation?**
- ↓ **Fertility?**
- ↓ **Body-weight at birth?**
- ↓ **Colostrum and milk?**
- ↓ **Post-natal development?**



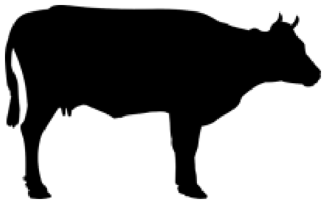
Introduction

Rumen digestion and colostrogenesis is sensitive to **fatty acid (FA) intake**

Feed FA is low, and mostly PUFA and SFA

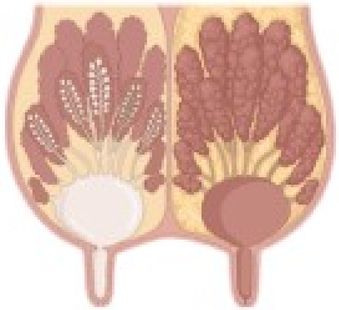


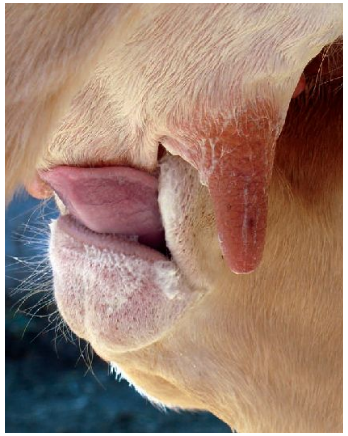
Undergo ruminal biohydrogenation



18:2n-6
Linoleic Acid
↓ *linoleate isomerase*
*c*9,*t*11-18:2
Rumenic Acid
↓ *reductase*
*t*11-18:1
Vaccenic Acid
↓ *reductase*
18:0
Stearic Acid

↑C18:2 n-6 intake may ↑ colostrum antibodies
Reviewed by Hare et al. (2023). Anim Frontiers 13 (3). 24–36. https://doi.org/10.1093/af/vfad031





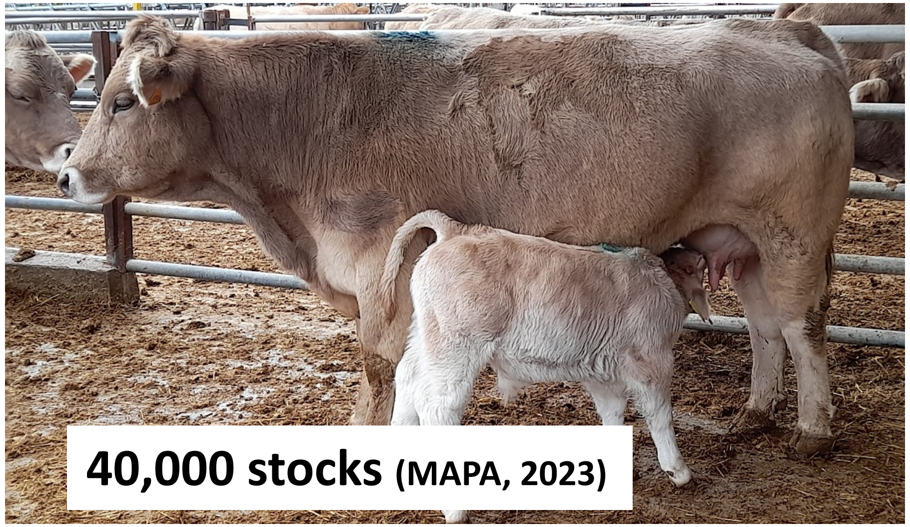
Perhaps a physiological mechanism in dams to protect the newborn through the mammary gland FA profile?

Vahmani et al. (2015) [10.1186/s40104-015-0026-z](10.1186/s40104-015-0026-z)

Introduction

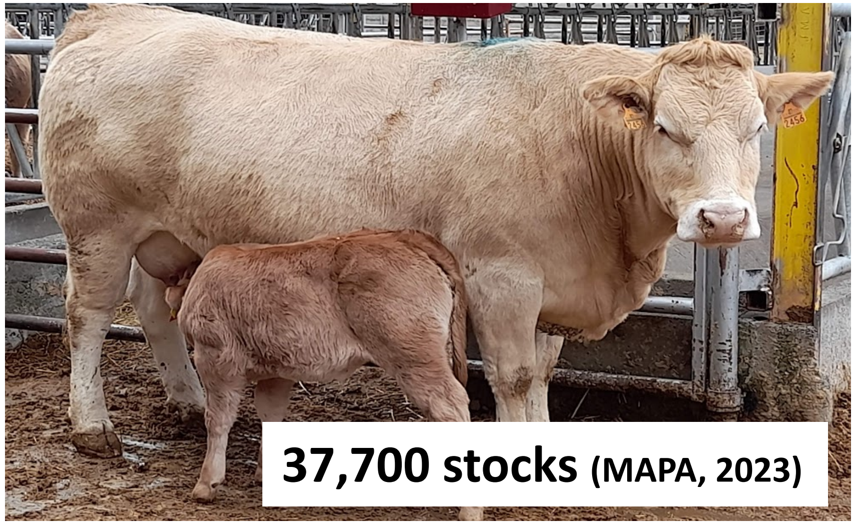
How do Spanish beef breeds cope with maternal undernutrition?

Parda de Montaña



Derives from Brown Swiss (grey-coated), introduced two centuries ago as a dual purpose breed (milk-beef)

Pirenaica



Derives from local hardy cows (blond-coated), Past triple purposes (work-milk-beef)

Background: **Parda de Montaña** showed *lower BCS at calving* and *higher calf BW at birth*, and *higher milk yield at week 3 post-partum* than **Pirenaica breed (11.0 vs. 9.3 kg/day)**, regardless of feeding level during the last trimester of gestation (Noya et al., 2022).

Objective

Aims

To evaluate the effects of **prepartum maternal nutrition** (60% vs. 100% of their nutritional requirements during 3 months before calving) and **beef breed** (Parda de Montaña vs. Pirenaica) on the **fatty acid profile of the colostrum and milk**.

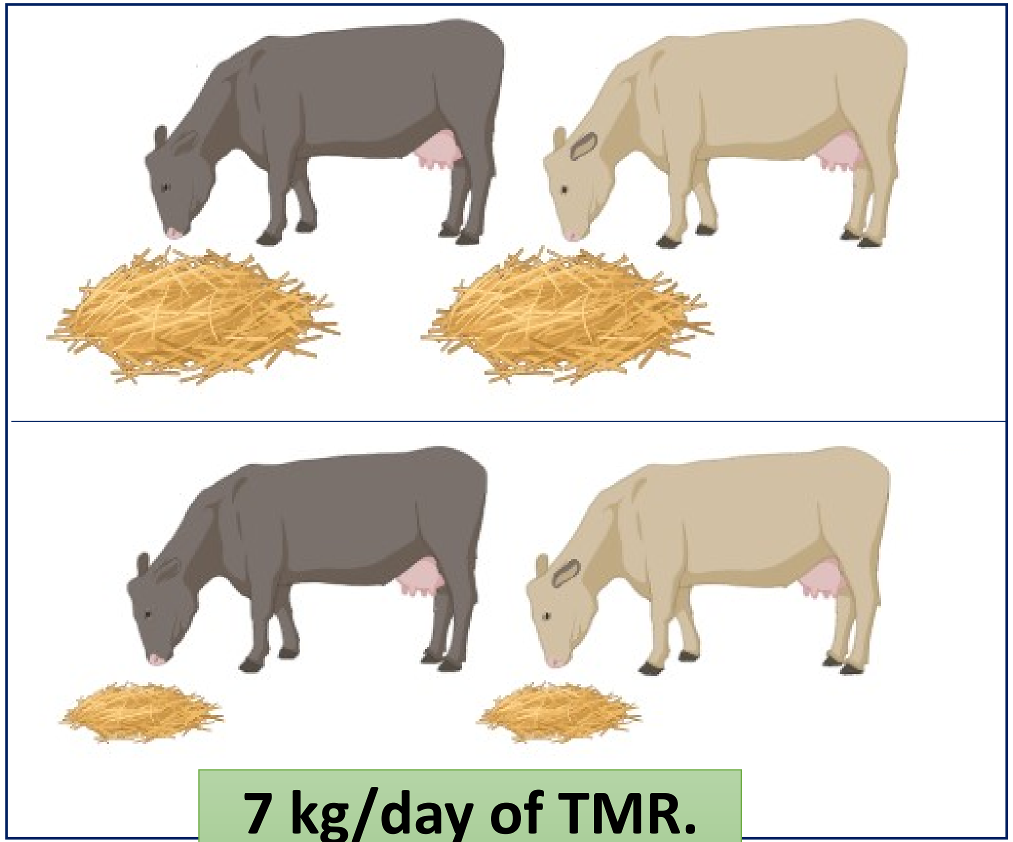
Material and methods

Experimental set-up

n=80 cows (autumn-winter season), 2 x 2 factorial design

Pregnancy

10.5 kg/day of TMR.
100% requirements

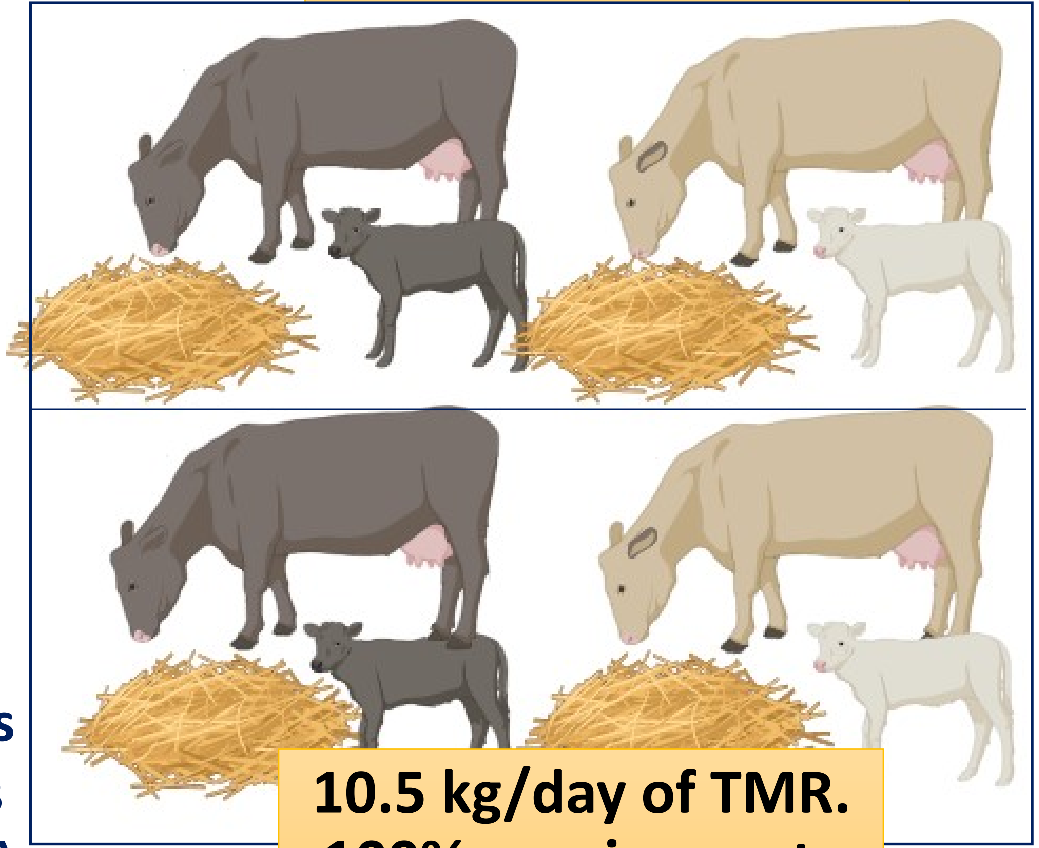


7 kg/day of TMR.
60% requirements

Eight separate loose-house pens (4 replicate pens per feeding level)

Lactation

10.5 kg/day of TMR.
100% requirements



10.5 kg/day of TMR.
100% requirements

Created in BioRender.com bio

Material and methods

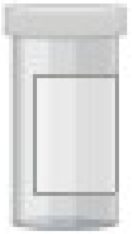
TMR ingredients:

- Barley straw (49.6%).
- Barley grain (24.8%).
- Alfalfa pellet (8.4%).
- Rapeseed meal (6.9%).
- Sugar-beef pulp (4.5%).
- Soybean meal (2.5%).
- Vitamins-minerals-additives (3.3%).

1240 kcal NE for lactation/kg DM

Total fatty acids (g/100 g of feed)	0.7	
g FA/100 g of fatty acid methyl esters in feed:		
C14:0. myristic	1.7	SFA
C16:0. palmitic (2nd)	29.8	SFA
C18:0. stearic	2.2	SFA
C20:0. arachidic	0.6	SFA
C18:1 cis-9. oleic (3rd)	12.9	MUFA
C18:1 cis-11. cis-vaccenic	2.1	MUFA
C18:2 n-6. LA. linoleic (1st)	37.1	PUFA
C18:3 n-3. ALA. α-linolenic	9.7	PUFA
C18:3 n-6. GLA. γ-linolenic	4.0	PUFA

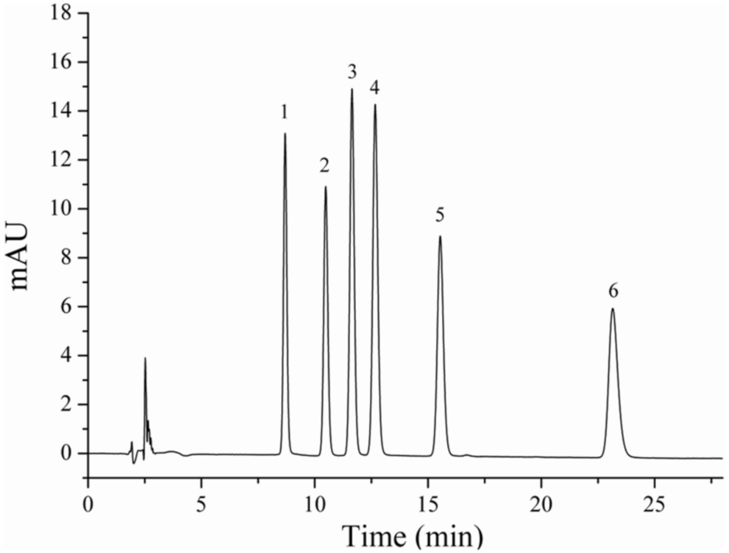
Sampling and processing



- **Colostrum** was manually milked <12h post-partum (80 ml in total, mixing 4 quarters).
- **Milk** was machine milked by oxytocin technique at week 3 post-partum (6-h interval between milking, 2 to 3 kg of milk recorded).
- 40-ml samples were freeze-dried. A variable amount of lyophilized milk was weighed to obtain approximately 40 mg of lipids (Giannuzzi et al.. 2022).
- Total solid contents of colostrum and milk were calculated as the proportion of freeze-dried residual out of the raw milk content.

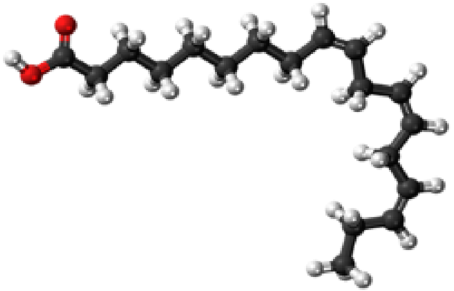
Fatty acids analysis

- Undecanoic acid (C11:0) was used as **internal standard**.
- The samples were directly methylated with sodium methoxide (Wilms et al., 2022).
- **Fatty acid methyl esters (FAME)** were analyzed with 7820A GC fitted with FID, auto sampler and a RTX-2330 column (105 m).
- **Nine** (for TMR diets) and **thirty-two** (for colostrum and milk) FAME peaks were identified by comparison with the peaks generated by injection of reference standards.
- The FAME were corrected for mass discrepancy based on determined **response factors**.



Statistical analysis

- The data were analyzed with the statistical package JMP Pro16 (SAS Institute Inc. Cary. NC. USA).
- Simple least squares models including the **feeding level** (100% or 60%) and **breed** (Parda or Pirenaica) as fixed effects.
- Single **interactions between fixed effects** were evaluated but they were finally removed from the model because **they were never significant** (P>0.05).



Results and discussion

Total solids and fatty acids content

	Diet		Breed			P-value	
Colostrum	**100%**	**60%**	**Parda**	**Pirenaica**	**SE**	**Diet**	**Breed**
Total solids (g/100 g of colostrum)	27.6	27.3	26.6	28.3	0.73	NS	NS
Total FA (g/100 g of colostrum)	4.95	4.32	4.97	4.3	0.52	NS	NS
Milk							
Total solids (g/100 g of milk)	13.7	13.1	12.8	14.0	0.13	**	***
Total FA (g/100 g of milk)	3.77	3.66	3.60	3.83	0.1	NS	NS

- ✓ **In colostrum, prepartum nutrient restriction did not affect total solids nor FA amount.**
- ✓ **In milk, total solid content was reduced by previous nutrient restriction and in Parda de Montaña breed, but this difference could not be attributed to the amount of FA only.**

<u>Colostrum</u> FA according to saturation

	Diet		Breed			P-value	
(g/100 g FA)	100%	60%	Parda	Pirenaica	SE	Diet	Breed
Total SFA	69,89	63,72	64,59	69,01	0,64	***	***
Total MUFA	23,07	28,65	27,62	24,10	0,58	***	***
Total PUFA n-3	1,96	2,26	2,37	1,84	0,08	**	***
Total PUFA n-6	4,34	4,39	4,50	4,23	0,09	NS	*
Rumenic acid (CLA c9,t11)	0,71	0,97	0,88	0,80	0,03	***	*

- ✓ **Nutrient-restricted cows decreased SFA at the expense of increasing MUFA, PUFA n-3 and rumenic acid content.**
- ✓ **Parda de Montaña breed had a similar response to nutrient-restricted cows, independently of feeding level.**

Results and discussion

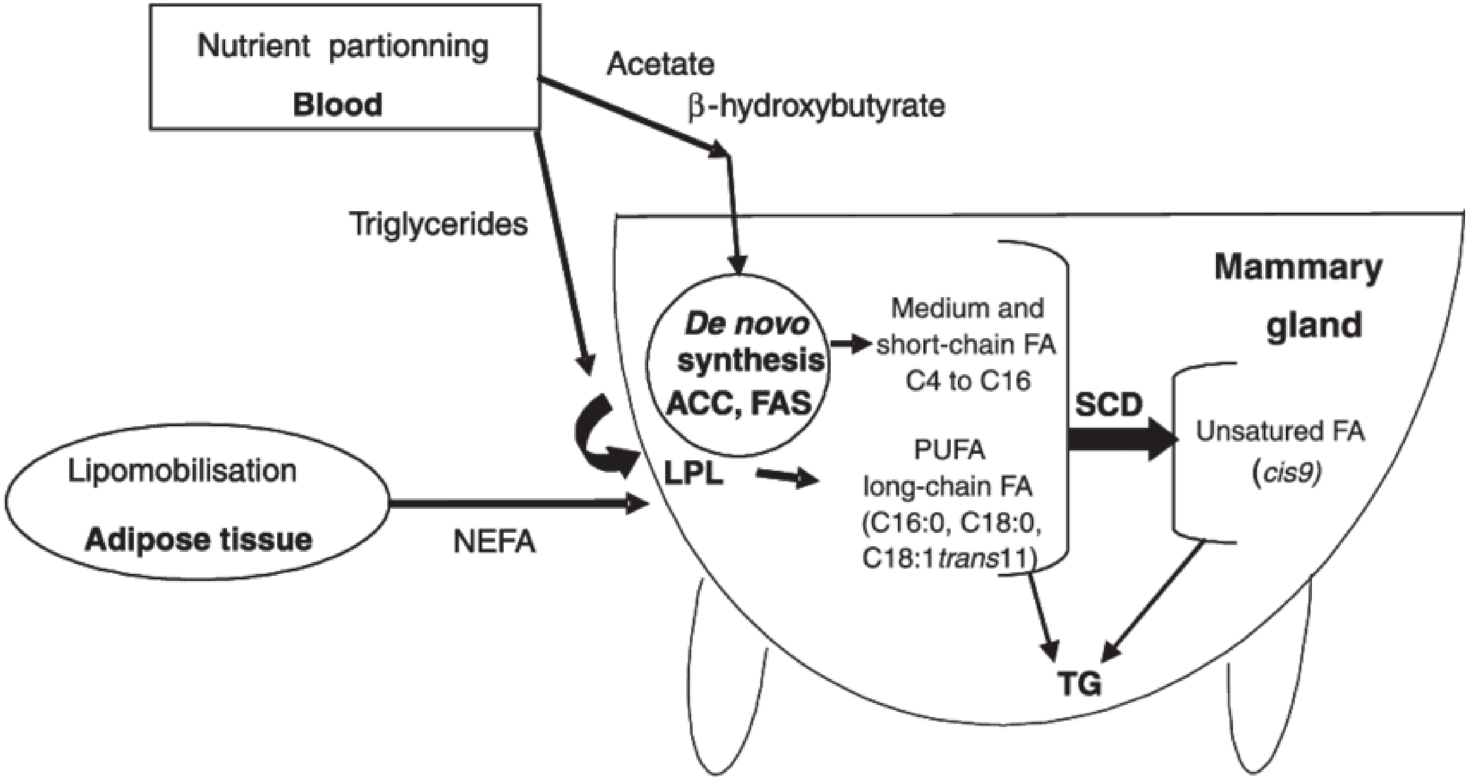
Milk FA according to saturation

	Diet		Breed			P-value	
(g/100 g FA)	**100%**	**60%**	**Parda**	**Pirenaica**	**SE**	**Diet**	**Breed**
Total SFA	64,85	65,04	64,31	65,57	0,63	NS	NS
Total MUFA	30,39	30,39	30,99	29,79	0,57	NS	NS
Total PUFA n-3	0,93	0,85	0,90	0,88	0,02	*	NS
Total PUFA n-6	2,55	2,44	2,50	2,49	0,05	NS	NS
Rumenic acid (CLA c9,t11)	1,28	1,27	1,29	1,26	0,04	NS	NS

- ✓ **Prepartum nutrient restriction did not affect the main milk FA at week 3 post-partum, but it reduced PUFA n-3 content.**
- ✓ **Both breeds showed similar FA profile in lactation.**

Three major pathways determining milk FA origin

1)	**De novo** synthesized fom VFA substrates (C4:0 to C15:0)
2)	**Mixed origin** from diet and tissue mobilization (C16:0+C16:1)
3)	Extracted from arterial blood or body adipose tissue **mobilization** (≥C17:0)



PUFA : PolyUnsaturated FA
NEFA : Non Esterified FA
TG : Triglycerides

ACC : Acetyl-CoA Carboxylase
FAS : Fatty Acid Synthase
LPL : LipoProtein Lipase
SCD : Stearoyl-CoA Desaturase

Leroux et al., 2003 https://doi.org/10.1051/rnd:2003032

Colostrum FA according to origin

	Diet		Breed			P-value	
(g/100 g FA)	**100%**	**60%**	**Parda**	**Pirenaica**	**SE**	**Diet**	**Breed**
De novo (C4:0 to C15:0)	21,31	17,73	17,66	21,37	0,41	***	***
Mixed origin (C16:0+C16:1)	43,61	38,48	38,94	43,15	0,68	***	***
Mobilization (≥C17:0)	35,08	43,79	43,39	35,48	0,96	***	***

- ✓ **Nutrient-restricted cows decreased *de novo* and mixed origin FA but increased mobilized FA in colostrum.**
- ✓ **Again, Parda de Montaña breed had a similar response to nutrient-restricted cows, independently of feeding level.**

Milk FA according to origin

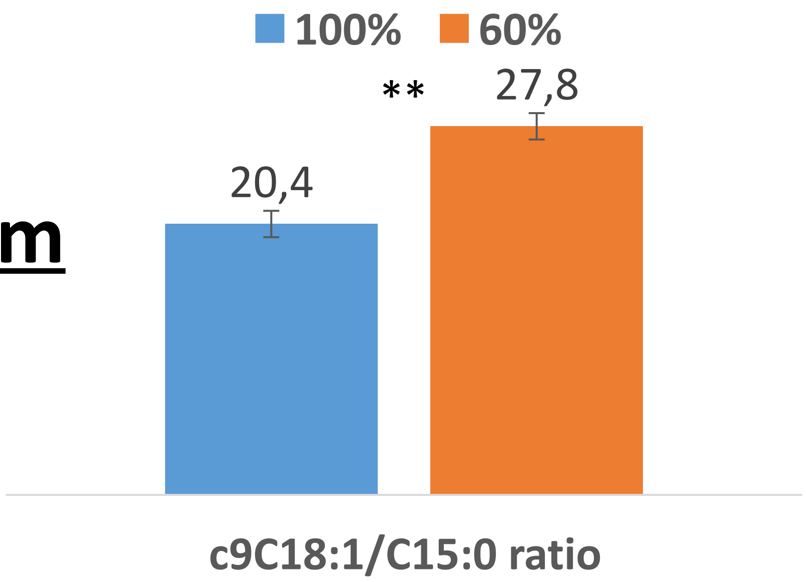
	Diet		Breed			P-value	
(g/100 g FA)	100%	60%	Parda	Pirenaica	SE	Diet	Breed
De novo (C4:0 to C15:0)	25,84	26,52	26,10	26,26	0,43	NS	NS
Mixed origin (C16:0+C16:1)	30,58	30,65	29,75	31,48	0,36	NS	***
Mobilization (≥C17:0)	43,58	42,83	44,14	42,26	0,68	NS	*

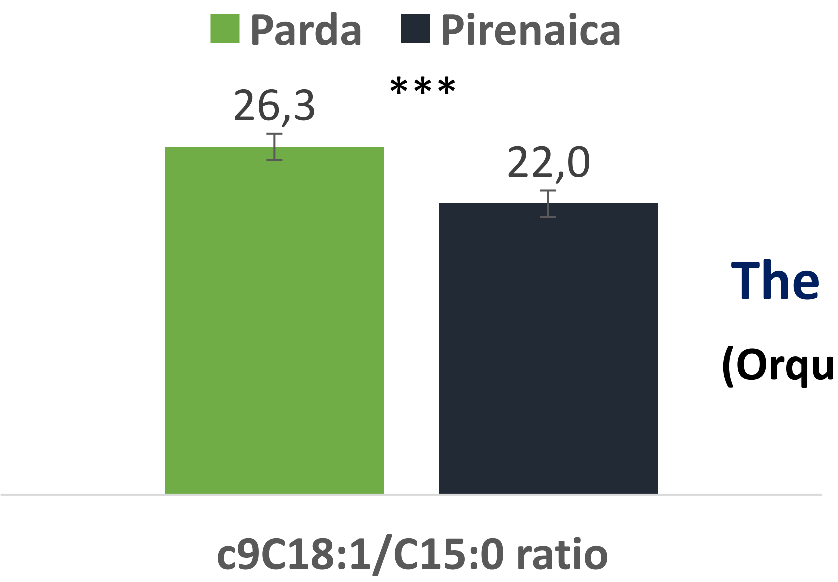
- ✓ **Prepartum nutrient restriction did not affect the milk FA origin at week 3 post-partum.**
- ✓ **Both breeds showed similar de novo FA content, but Parda de Montaña had lower of mixed origin and higher mobilized FA in milk than Pirenaica cattle.**

Results and discussion

Metabolic status indicator ratio

Colostrum



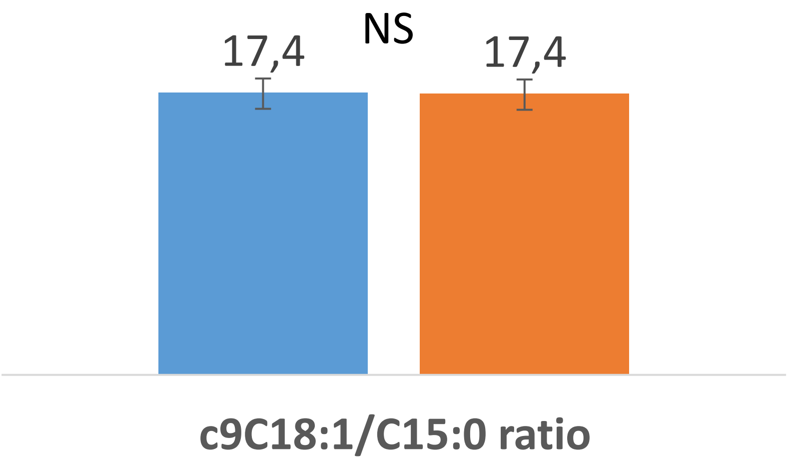


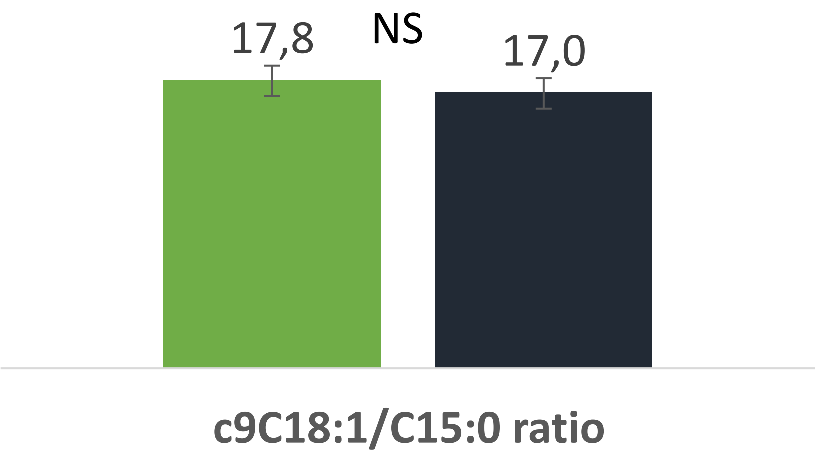
The higher, the worse

(Orquera-Aguero et al. 2023)

Undernutrition and breed led to metabolic challenge around calving but they subsequently recovered

Milk





Conclusions

- **Beef cow undernutrition** (last trimester of pregnancy) did not affect colostrum and milk total FA, but **boosted beneficial MUFA, rumenic acid and PUFA n-3 at the expense of SFA content.** Milk FA differences were nearly **vanished** with the post-partum refeeding strategy.
- **Parda de Montaña cattle breed** incorporated more rumenic acid, MUFA, PUFA n-3 into colostrum but not in milk, compared with **Pirenaica**, regardless of earlier nutrient restriction.

Thank you for your attention!

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