

Variations in milk yield and regulation of lactose and casein synthesis

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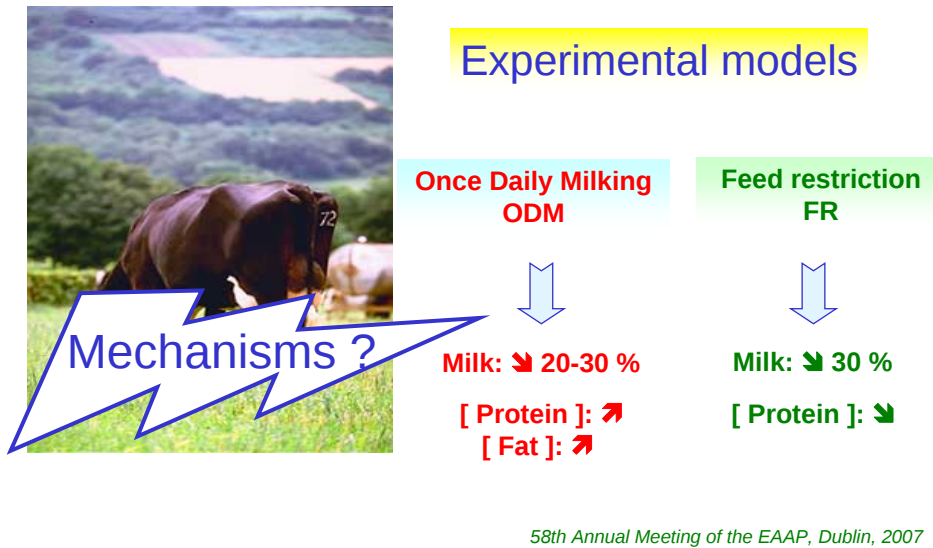
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Variations in milk yield and regulation of lactose and casein synthesis

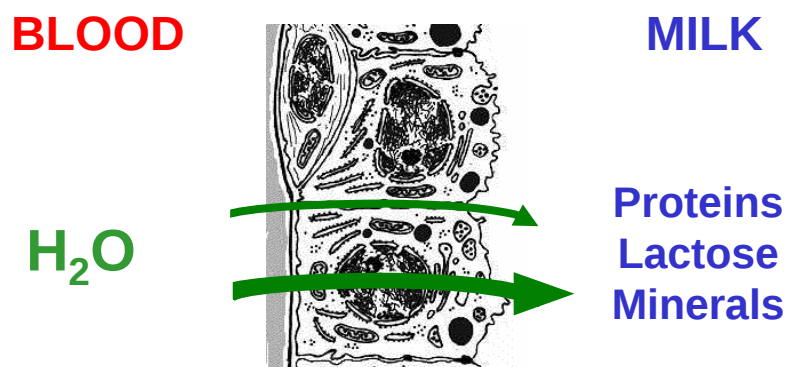
The present presentation is a review of the main factors reducing highly milk yield, to highlight the mechanisms involved in the regulation of milk lactose and protein production. These mechanisms determine the amount of glucose and amino acids taken up by the udder and metabolised either in lactose or proteins. The mammary blood flow that supplies nutrients to the udder plays an important role when milk yield is depressed by 20-30%. However, the reduced arterial availability of nutrients to the udder is not the only mechanism involved. The ability of the udder to extract nutrient could be affected either by altered transmembrane transport or by lower intra-cellular metabolic activity. Indeed, feed restriction reduces the ARNm levels of transmembrane transporters of glucose. The amount and activity of the enzymes responsible for the synthesis of milk components are also regulated. In addition to the lowered ARNm levels of caseins, once daily milking induces a decline in the activity of galactosyltransferase, the enzyme of the lactose synthase complex and in the ARNm levels of its co-factor, the α -lactalbumin.

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Important variations in milk yield



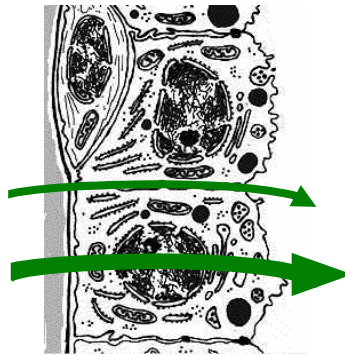
Water transfer into milk



Water transfer into milk

BLOOD

H_2O



MILK

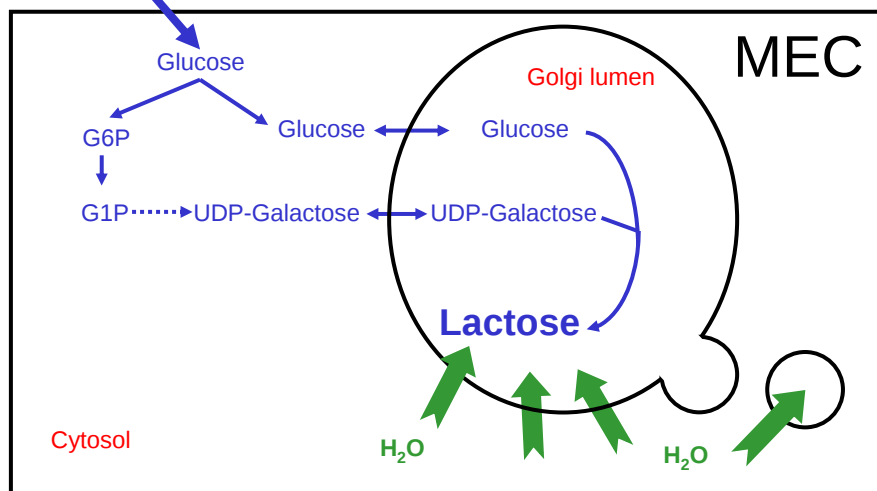
major osmotic agent

Proteins
Lactose
Minerals

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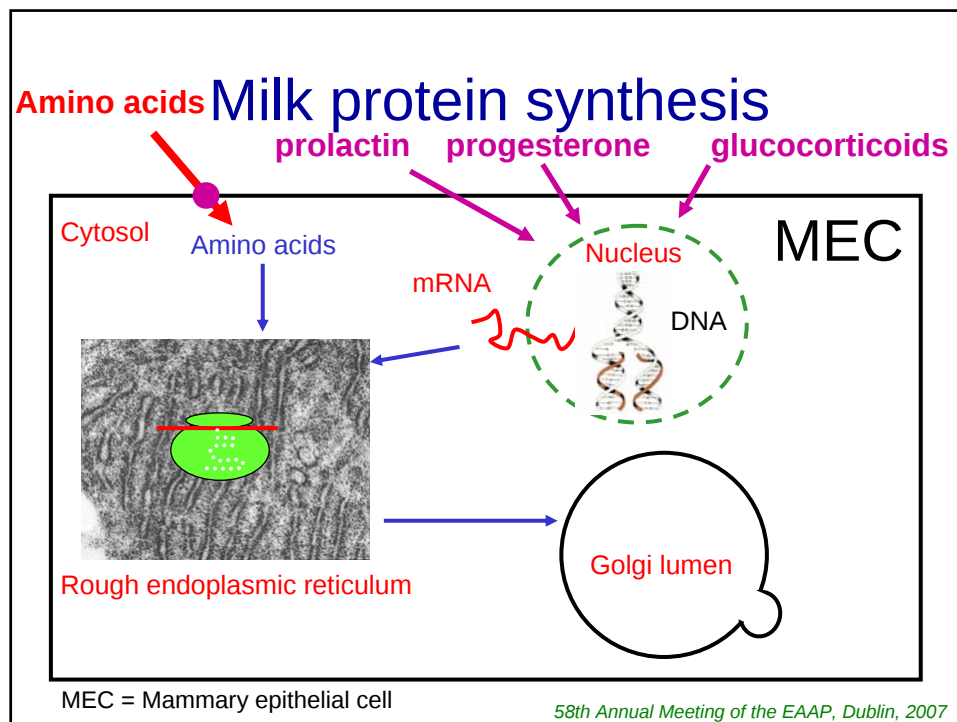
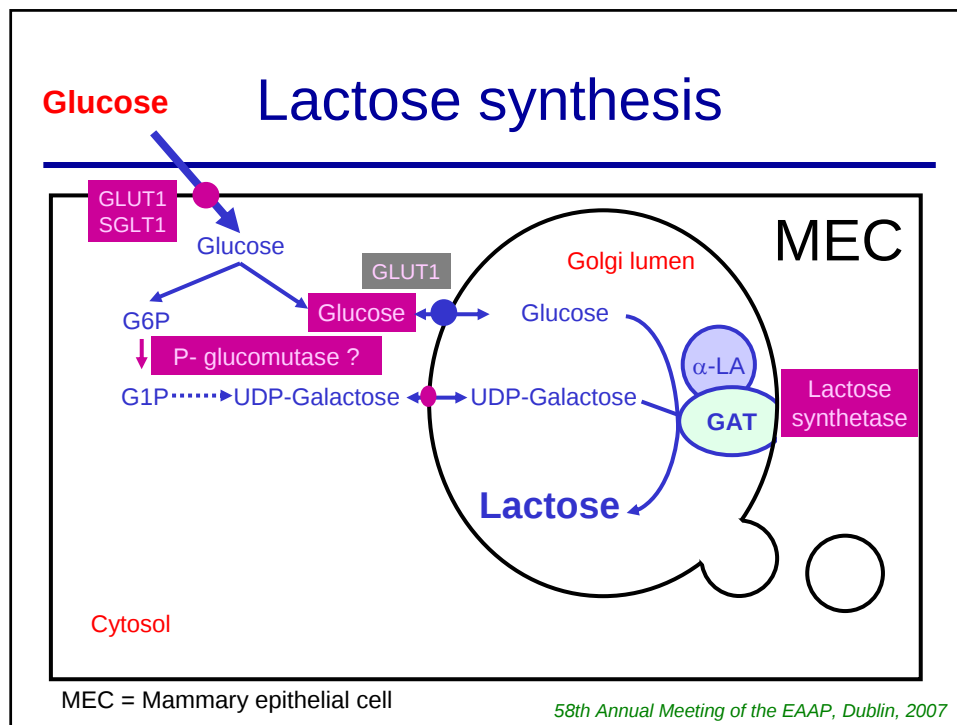
Glucose

Lactose synthesis

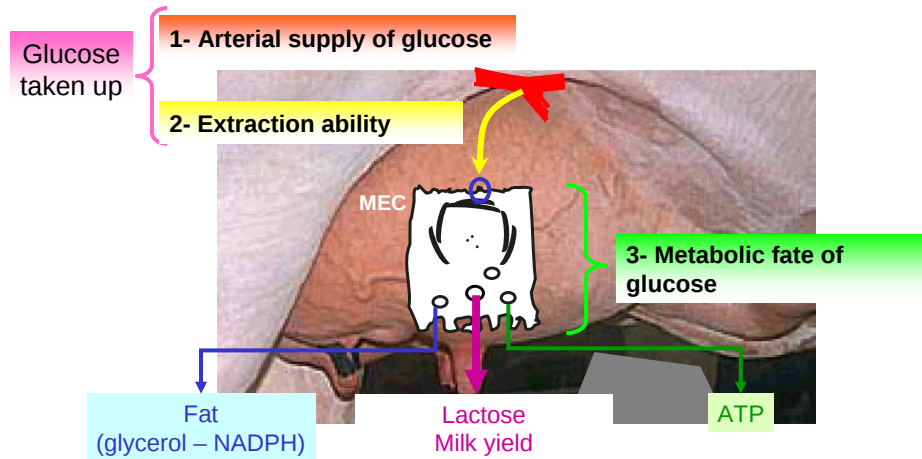


MEC = Mammary epithelial cell

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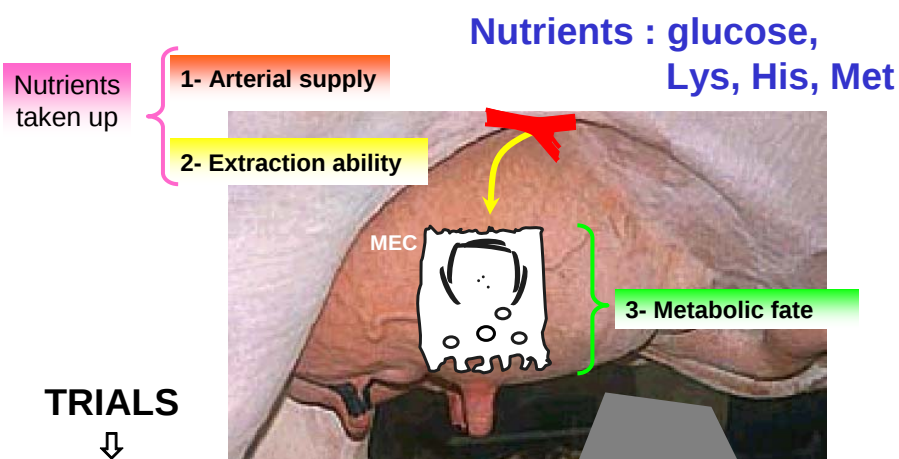


Three mammary levels of regulation



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Which effects of ODM and FR?



Once vs. twice daily milking

Fasting ⇒ 10% restriction

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1) The arterial supply of nutrients to the udder ?

$$\text{Arterial supply} = \text{mammary blood flow} \times [\text{ }]_{\text{arterial}}$$

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ODM

FR

↓
(except Lys)

Arterial supply



10-17%



Mammary blood flow



15%

8%



27%



(Lys)

[Glucose]_{arterial}
[Limiting EAA]_{arterial}

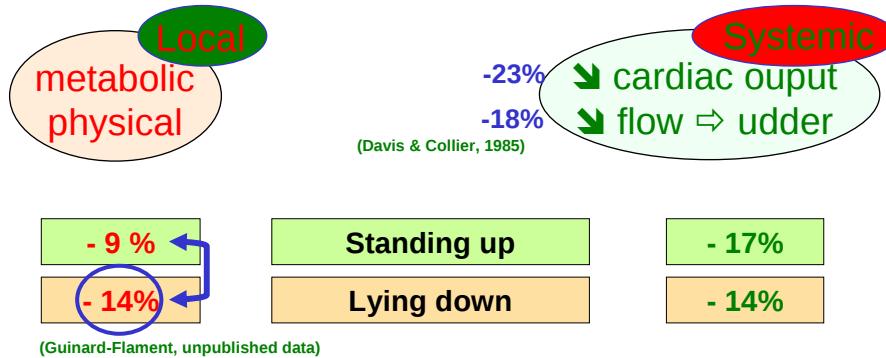


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ODM

FR

Why a ↓ mammary blood flow?



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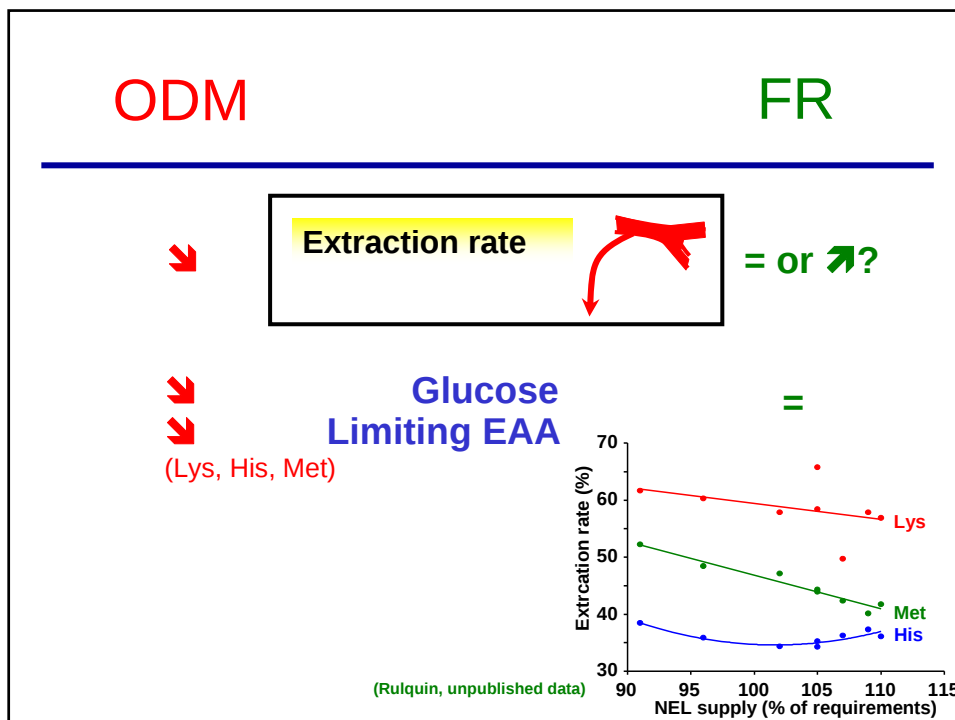
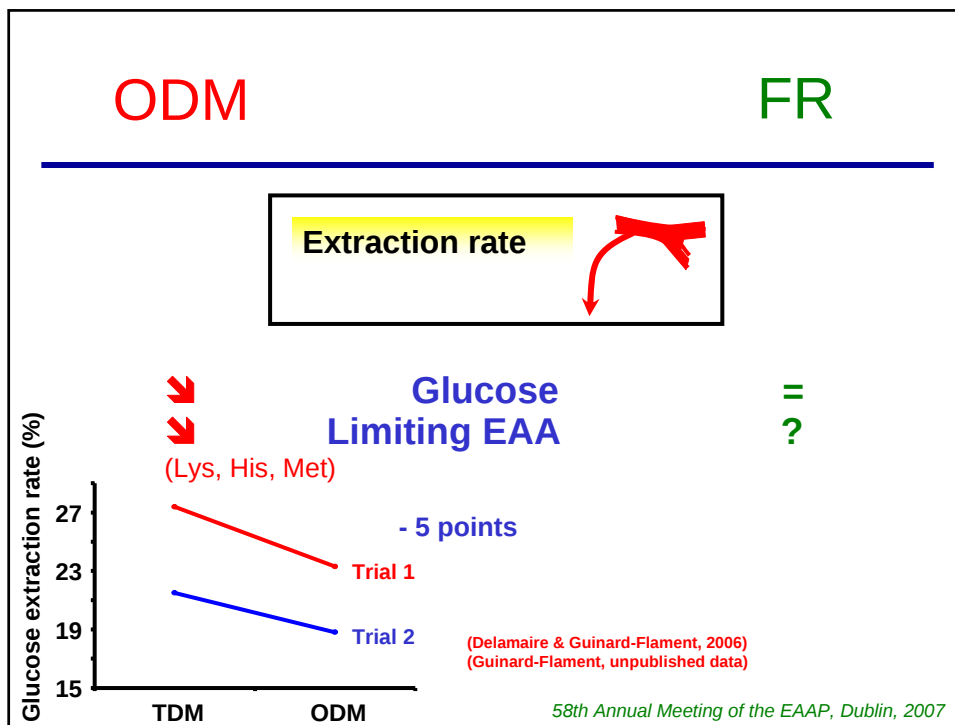
2) Udder's ability to extract nutrients?
Quantity of nutrients taken up?

Extraction ability :

- Extraction rate = $([\text{arterial}] - [\text{venous}]) / [\text{arterial}] \times 100$

Uptake = Arterial supply x extraction rate

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ODM

FR

Why the extraction rate decreases

Transmembrane transporters ?



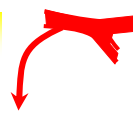
Transcription
Post-transcription $\Rightarrow$ localisation

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ODM

FR

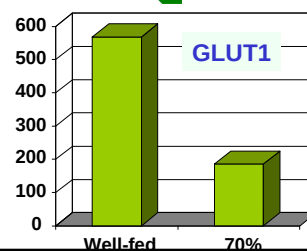
Extraction rate

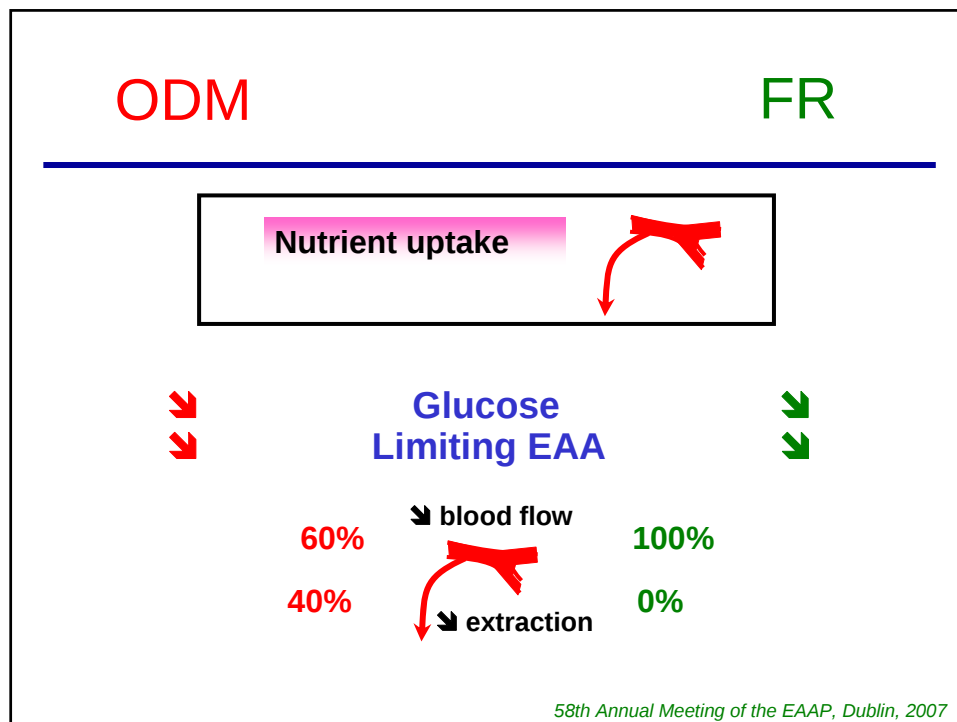


Glucose
mRNA GLUT1
mRNA SGLT1

=
70%
70%

Relative mRNA level in
isolated milk MEC
(/cyclophilin)
(Boutinaud, unpublished data)





3) Metabolic fate of nutrients?

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ODM

FR

↘ metabolic activity



enzyme activity?



Galactosyltransferase

=



Phosphoglucomutase

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ODM

FR

↘ metabolic activity



Galactosyltransferase

=

prolactin

⇒ mRNA levels?



α-lactalbumine

=

=

galactosyltransferase

=



Kappa-casein

=

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ODM

FR

↓ metabolic activity



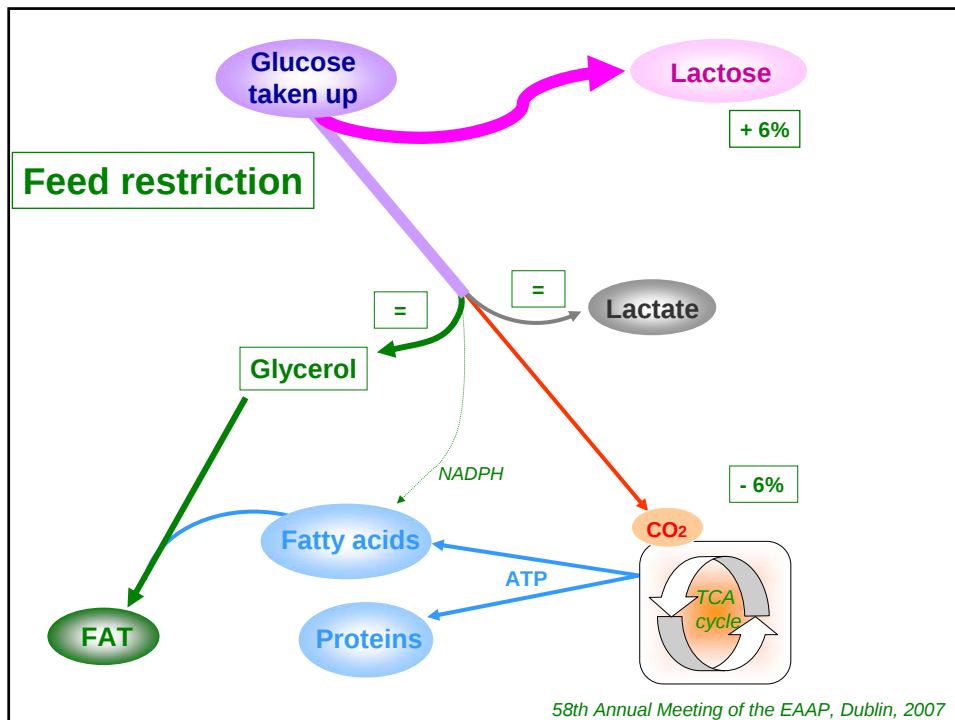
coupled or not with
a modification of the metabolic pathways
of nutrients taken up?

=
=

Glucose
Limiting EAA



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ODM

FR

↘ metabolic activity

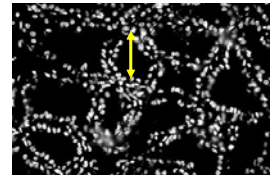
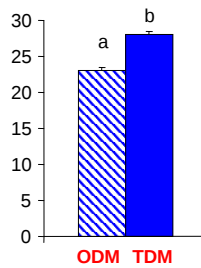
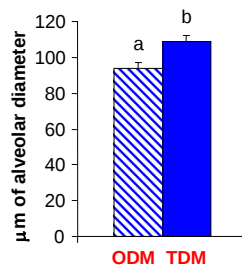


number of cells?

↗ apoptosis

↘ alveolar diameter

↘ number of MEC/alveole



(Boutinaud et al., 2003)

ODM

FR

↘ metabolic activity



number of cells?

↗ apoptosis

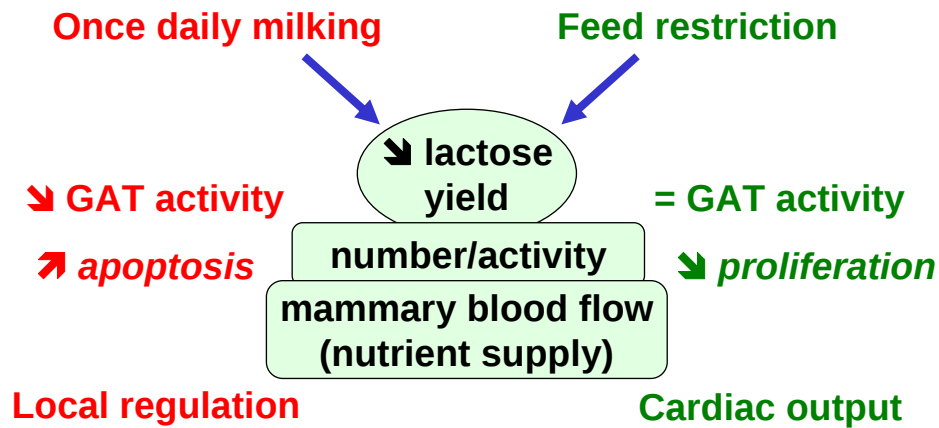
↘ proliferation

~~apoptosis~~

(Norgaard et al., 2005)

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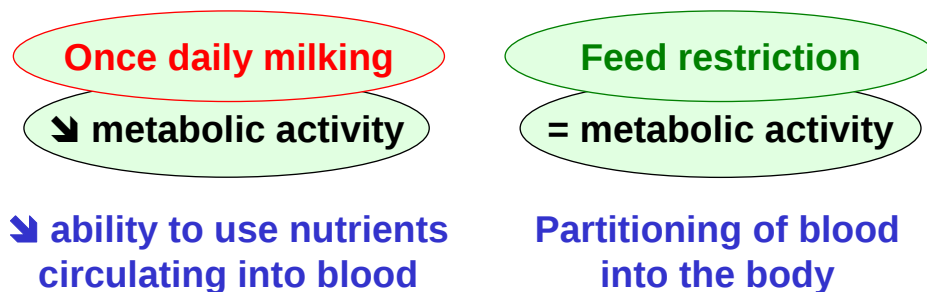
Conclusions



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Conclusions

↓ in milk and protein yields



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Conclusions

↘ in milk and protein yields

Complex mechanisms

Once daily milking

Feed restriction

independent - cumulative

When switched to once daily milking, restricted cows have lower milk yield than well-fed cows

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Thanks for attention



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