

# Effects of nature of forage and feeding restriction on milk lipolytic system

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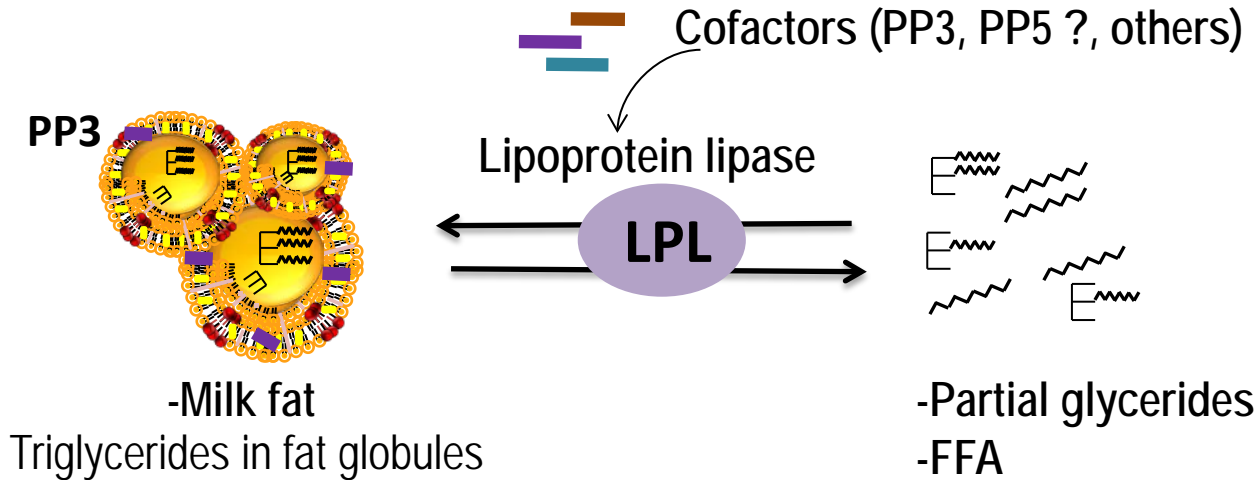
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# Introduction: Presentation of milk lipolytic system

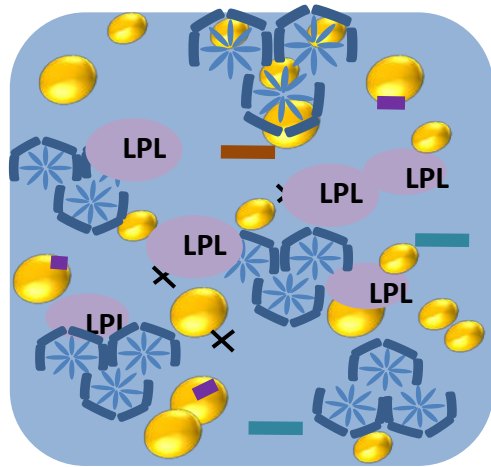


- **Lipolysis** = Enzymatic hydrolysis of triglycerides into glycerol and free fatty acids (FFA) by lipoprotein lipase

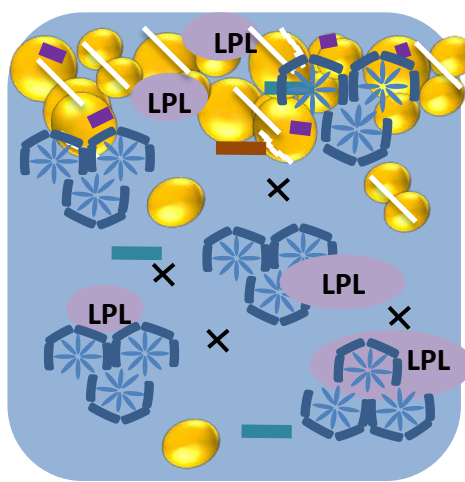
# Introduction: Lipolysis, a zootechnical problem

- **FFA are responsible for off-flavour (oxidized) in milk and dairy products**  
(Mac Leod et al., 1957 ; Connolly et al., 1979 ; Santos et al., 2003)
- **Partial glycerides and FFA are responsible for technological abilities impairment** (Buchanan, 1965 ; Deeth and Fitzgerald, 1995 ; Deeth, 2006)
- **Lipolysis is an economical issue (farmers, dairies)**
- **Key figures:**
  - **1.2 – 1.5 mEq/100 g fat: threshold of acceptance for consumers** (Chilliard and Lamberet, 1984 ; Mac Leod et al., 1957 ; Connolly et al., 1979 ; Santos et al., 2003)
  - **0.89 mEq/100 g fat: threshold for milk payment to farmers** (CNIEL)

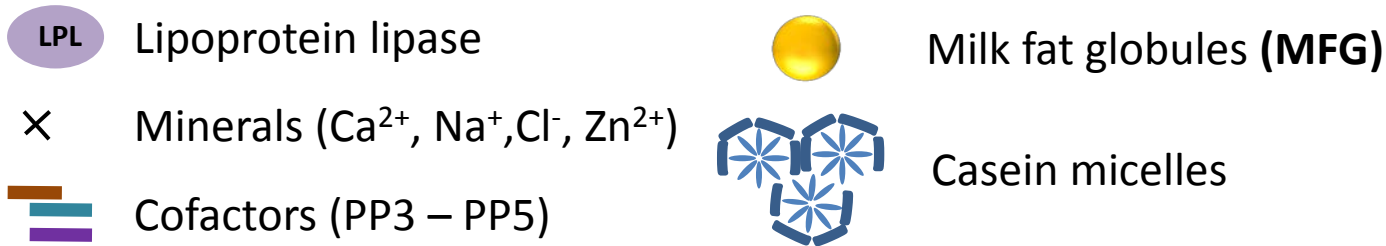
# Introduction: Mechanisms of milk lipolytic system



Cooling

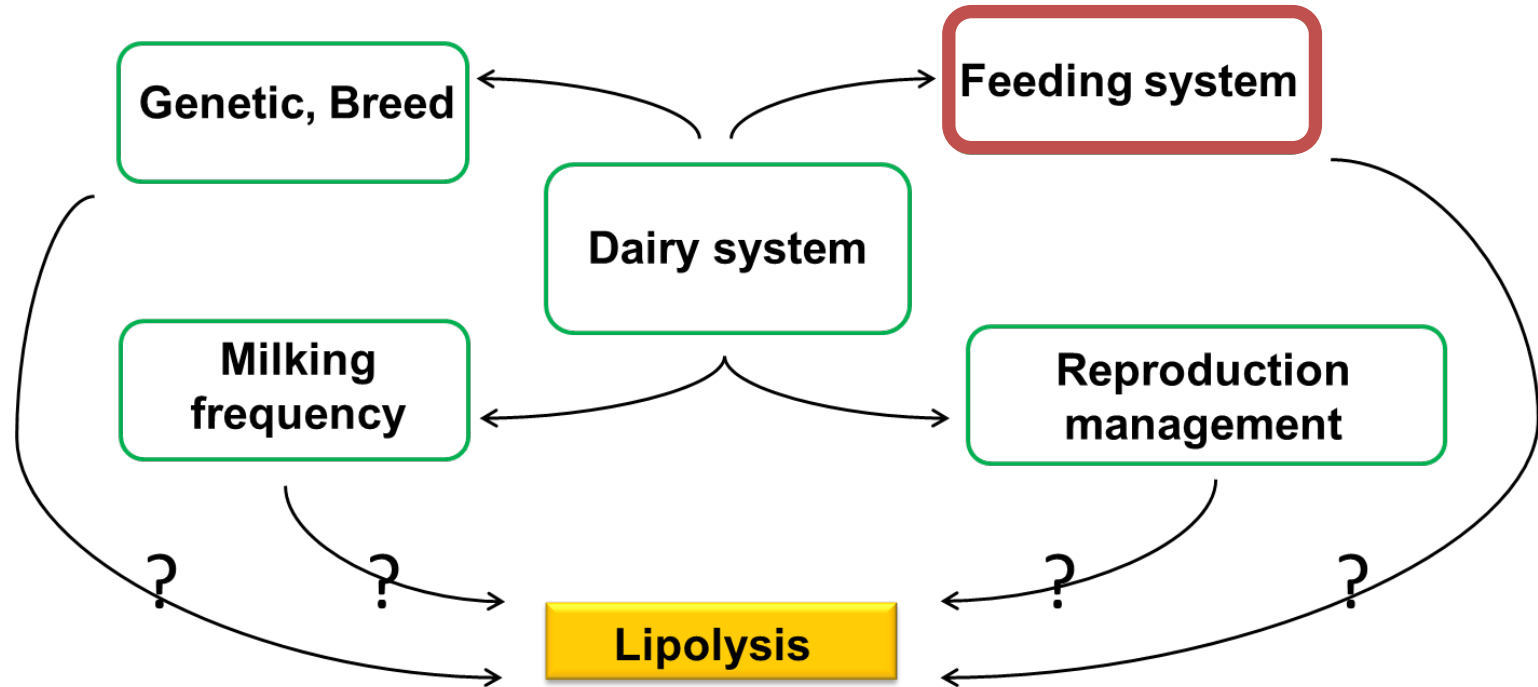


- Loss of integrity of MFG
- Migration of LPL
- Cofactors (PP3 – PP5) ?  
Balance activators /inhibitors



Dickow et al., 2011

# Introduction: Feeding systems impact on lipolysis

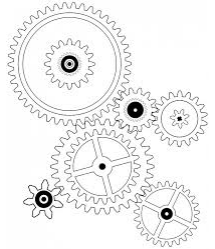
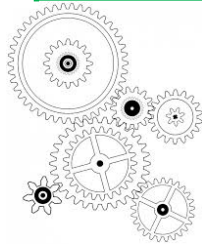
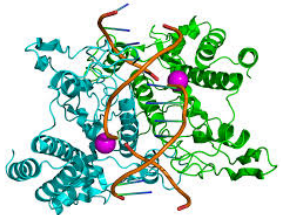


# Introduction: Scientific issue



**What is the impact of nature of forage and feeding restriction on lipolysis? What are the biochemical mechanisms?**

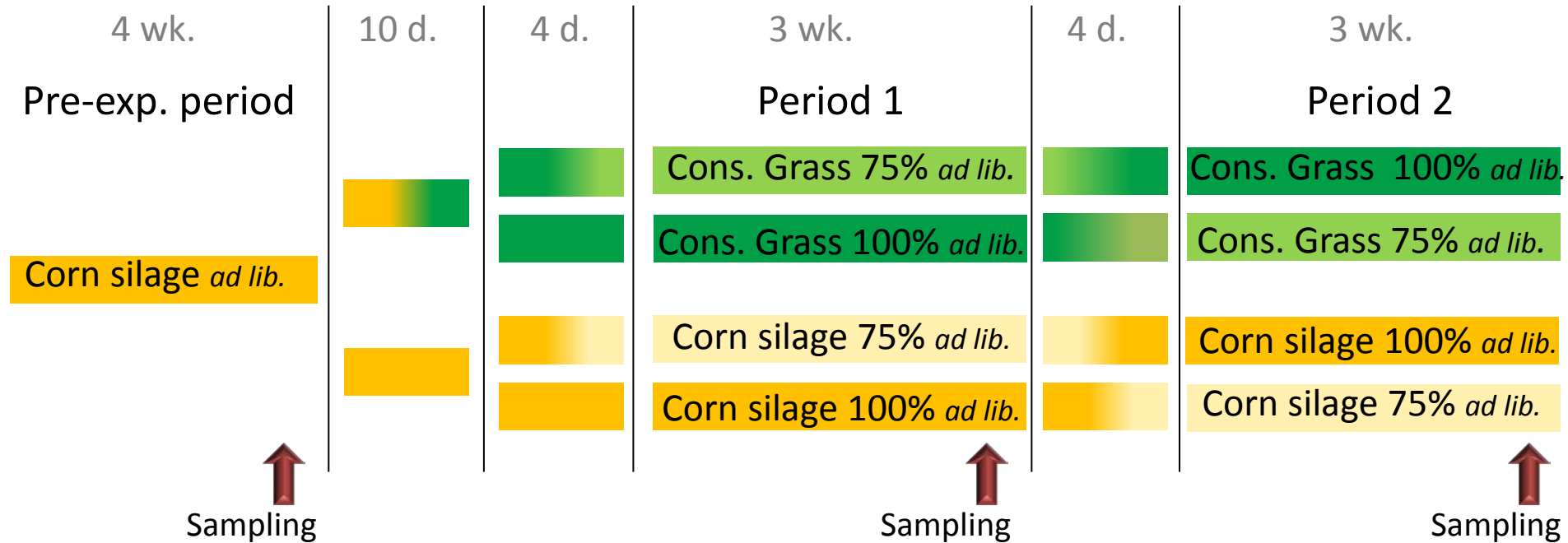
Role of MFG, LPL activity and cofactors



# Material and Methods: Experimental design



➤ 32 Holstein multiparous cows, mid lactation



# Material and Methods: Measurements and statistical analysis

## ➤ Measurements and laboratory analysis

- Milk yield, fat and protein contents
- Lipolysis
- LPL activity
- MFG size
- Protein profile on 12 milks (potential LPL cofactors)
- Non esterified fatty acids (NEFA)

## ➤ Statistical analysis

- Effects of forage and feeding restriction on parameters: SAS MIXED procedure
- Correlations between lipolysis and parameters: SAS CORR procedure (Pearson)



# Results & discussion

Milk and plasma indicators of diet composition and feeding restriction were consistent with literature

	Corn	Grass
Milk yield, kg/d	32.3 <sup>a</sup>	30.1 <sup>b</sup>
Fat content, %	3.38 <sup>b</sup>	3.76 <sup>a</sup>
Protein content, %	2.95	3.00

- **Conserved grass was associated with lower milk yield (- 2.2 kg/d) and consequent higher fat content (+ 0.38%)**

# Results & discussion

Milk and plasma indicators of diet composition and feeding restriction were consistent with literature

	100% <i>ad lib.</i>	75% <i>ad lib.</i>
Milk yield, kg/d	33.4 <sup>a</sup>	29.0 <sup>b</sup>
Fat content, %	3.53	3.60
Protein content, %	3.04 <sup>a</sup>	2.91 <sup>b</sup>
NEFA, $\mu\text{M/L}$	185 <sup>b</sup>	368 <sup>a</sup>

➤ Feeding restriction was accompanied by

- a decrease in milk yield (- 4.4 kg/d) and protein content (- 0.13%)
- a two fold increase in NEFA (+ 184  $\mu\text{M/L}$ )

Delaby et al., 2009; Hurtaud et al., 2009; Burke et al., 2010

# Results & discussion

## Effect of forage and feeding restriction on lipolysis – morning milks

	Corn	Grass
Lipolysis, mEq/100 g fat	0.41 <sup>a</sup>	0.21 <sup>b</sup>

	100% <i>ad lib.</i>	75% <i>ad lib.</i>
Lipolysis, mEq/100 g fat	0.26 <sup>b</sup>	0.36 <sup>a</sup>

- In morning milks,
  - Effect of nature of forage: - 0.20 mEq/100g for conserved grass fed cows
  - Slight effect of feeding restriction: + 0.10 mEq/100g fat for restricted cows

# Results & discussion

## Effect of forage and feeding restriction on lipolysis – evening milks

	Corn	Grass
Lipolysis, mEq/100 g fat	0.77	0.70

	100% <i>ad lib.</i>	75% <i>ad lib.</i>
Lipolysis, mEq/100 g fat	0.60 <sup>B</sup>	<u>0.88<sup>A</sup></u>

➤ In evening milks,

- No effect of nature of forage
- Strong effect of feeding restriction: + 0.28 mEq/100g fat for restricted cows  
threshold for milk payment

# Results & discussion

## Effect of forage and feeding restriction on lipolysis

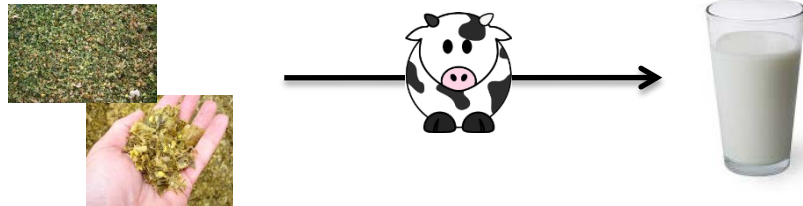
- **Feeding restriction enhanced lipolysis**
  - **Conserved grass reduced lipolysis / corn silage**
- } **Consistent with previous studies**

Chilliard et al., 1982; Chazal et al., 1987 ; Ferlay et al., 2006

Stobbs et al., 1973 ; Jellema, 1975 ; Deeth et Fitzgerald 1976 ; Connolly 1978 ; Jellema 1986 ; Chilliard et al., 1986; O'Brien 1996

- **BUT different effect on morning and evening milks**

- **Mechanisms ?**



# Results & discussion

## Effect of forage and feeding restriction on lipolytic system: LPL activity

		Corn	Grass			100% <i>ad lib.</i>	75% <i>ad lib.</i>
LPL activity, nmol/ min/ mL	MM	819	786	LPL activity, nmol/ min/ mL	MM	802	812
	EM	823	799		EM	801	822

- **No effect of forage and feeding restriction on total LPL activity**
- **Lipolysis and total LPL activity are not correlated ( $p > 0.05$ )**

(Bachman et Wilcox, 1990b ; Cartier, 1987 ; Olivecrona et al., 1980 ; Deeth et Fitzgerald , 1975)

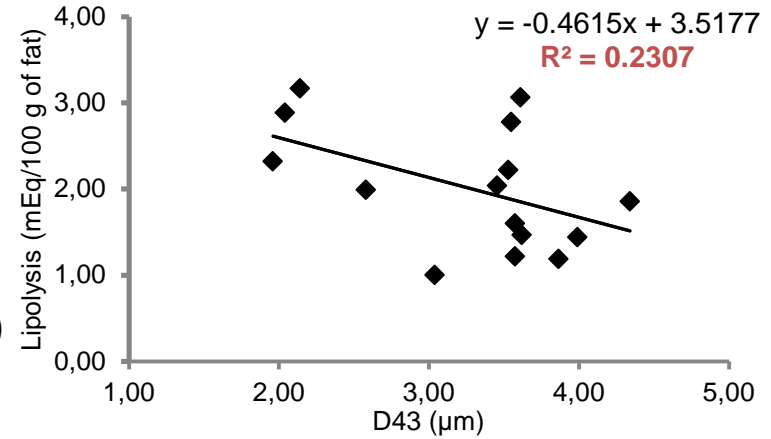
# Results & discussion

## Effect of forage and feeding restriction on lipolytic system : MFG size

		Corn	Grass
$D_{43}$ , $\mu\text{m}$	MM	3.28 <sup>b</sup>	3.61 <sup>a</sup>
	EM	3.56 <sup>b</sup>	3.82 <sup>a</sup>

- **MFG larger (+ 0.3  $\mu\text{m}$ ) when cows fed with conserved grass (higher fat content)**

(Couvreur and Hurtaud, 2007 ; 2016)



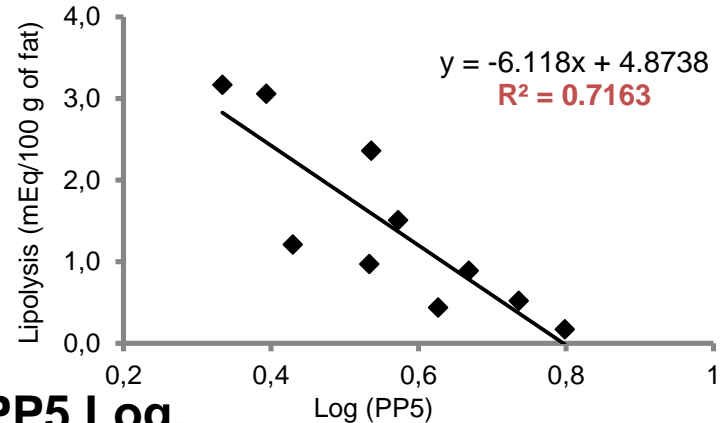
- **Among susceptible milks (lipolysis > 1mEq /100 g fat), small correlation between lipolysis and MFG size for corn silage fed cows**
- **Higher lipolysis with smaller MFG  $\longleftrightarrow$  membrane composition**

# Results & discussion

## Effect of forage and feeding restriction on lipolytic system : cofactors

		Corn	Grass
PP5, %	EM	0.86 <sup>b</sup>	2.76 <sup>a</sup>

- **PP5 percentage higher when cows fed with conserved grass**
- **Good correlation between lipolysis and PP5 Log.**
- **Inhibition of lipolysis by PP5**
- **No correlation between lipolysis and other milk proteins**





# Take home messages

## Animal level



- Feeding restriction enhanced lipolysis and the effect was higher in evening milks
  - Conserved grass based diets reduced lipolysis in morning milks
- 

## Biochemical level



- No effect of total lipoprotein lipase activity  
→ measure lipoprotein lipase activity in milk fat fraction
- Small effect of MFG size in susceptible milks of cows fed with corn silage  
Higher lipolysis with small MFG ↔ membrane composition
- Inhibitory effect of PP5

## Special thanks:

- Staff of Experimental farm Méjusseaume for animal care
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**THANK YOU FOR YOUR  
ATTENTION**

