

Cows' feeding and milk and dairy product sensory properties: a review

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Context

Erosion in consumer confidence in dairy products

Safety, environmental and nutritional issues

**Increasing demand about knowledge
of animal management**

Positive image of grass based diets

**Increasing demand for « terroir » products
with high sensory quality**

Animal feeding is part of the « terroir »

**Link between animal feeding and
milk and dairy products sensory quality?**

Context

Why?

To answer the questions of PDO cheese producers

Link to “terroir”

Reflexion about specifications for milk production

In France: 45 PDO cheeses, 12% of the cheese production, 5% of the milk production



Comté



Cantal



Roquefort



Reblochon



St-Nectaire

2/3 of the PDO cheeses originate from mountain areas
→ sustainability of farmers

Now, a demand of other types of products

Animal feeding and
sensory properties of dairy products

So far:

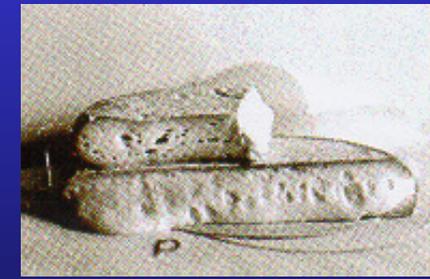
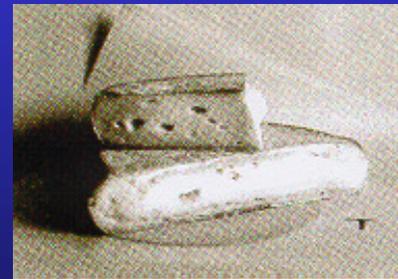
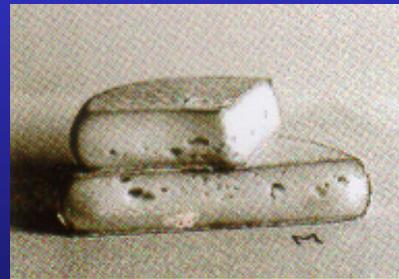
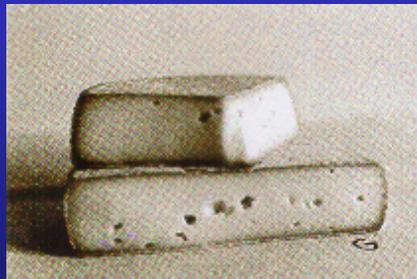
Many empirical observations but few experimental works

The sensory characteristics of milk and dairy products first depends on technological process !

1 raw material = huge diversity of dairy products

**The milk characteristics play a major role
when modifications of milk are restricted**

In similar processing conditions,
we observe great sensory differences :



Reblochon cheeses made with different milks

Martin et al., 1997

**Could these differences be linked
to cows' feeding ?**

**A focus on cattle milk and cheese
sensory properties linked to forages**

Milk sensory properties

Cheese sensory properties

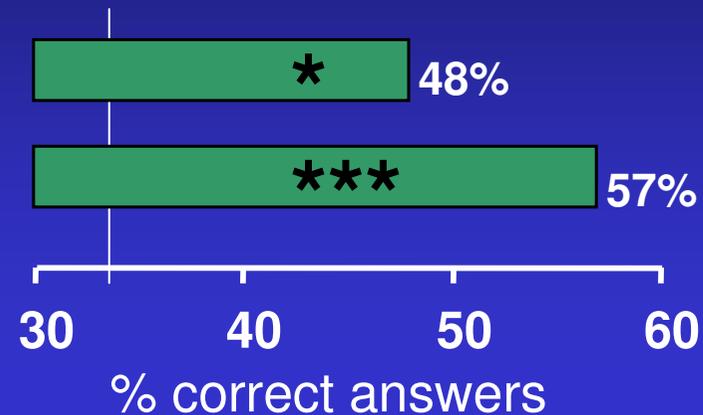
Sensory properties of milk according to the nature of the forage

Raw milk

Pasture vs Hay (86%)

Pasture vs Concentrate (65%) + Hay

More intense** odour and higher barn odour**



Results obtained by Triangle tests, in red light.
Dubroeuq et al., 2002; T° milk: 20 or 40 °C

Pasteurised milk

Total Mixed Ration

Maize + Alfalfa Silage (55%) + Concentrate

VS

Pasture (60%) + Concentrate

Croissant et al., 2009

Pasture → higher grassy** and cow/barn flavours** and lower sweet flavours**

Trained panel, T° milk: 15 °C

No effect of diet on consumer acceptance scores

Consumer panel, T° milk: 7 °C

Sensory properties of milk according to the nature of the forage

Raw milk

Pasture vs Hay (86%)



Pasture vs Concentrate (65%) + Hay



Flavour of pasture milk derive from a complex combination of a wide variety of aroma active compounds including: acids, esters, sulfur compounds, indole, skatole, terpenes....

Urbach et al., 1990; Moio et al., 1996; Bendal 2001;
Croissant et al., 2009; Coppa et al., 2011 ...

Total Mixed Ration
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Croissant et al., 2009

lower sweet flavours**

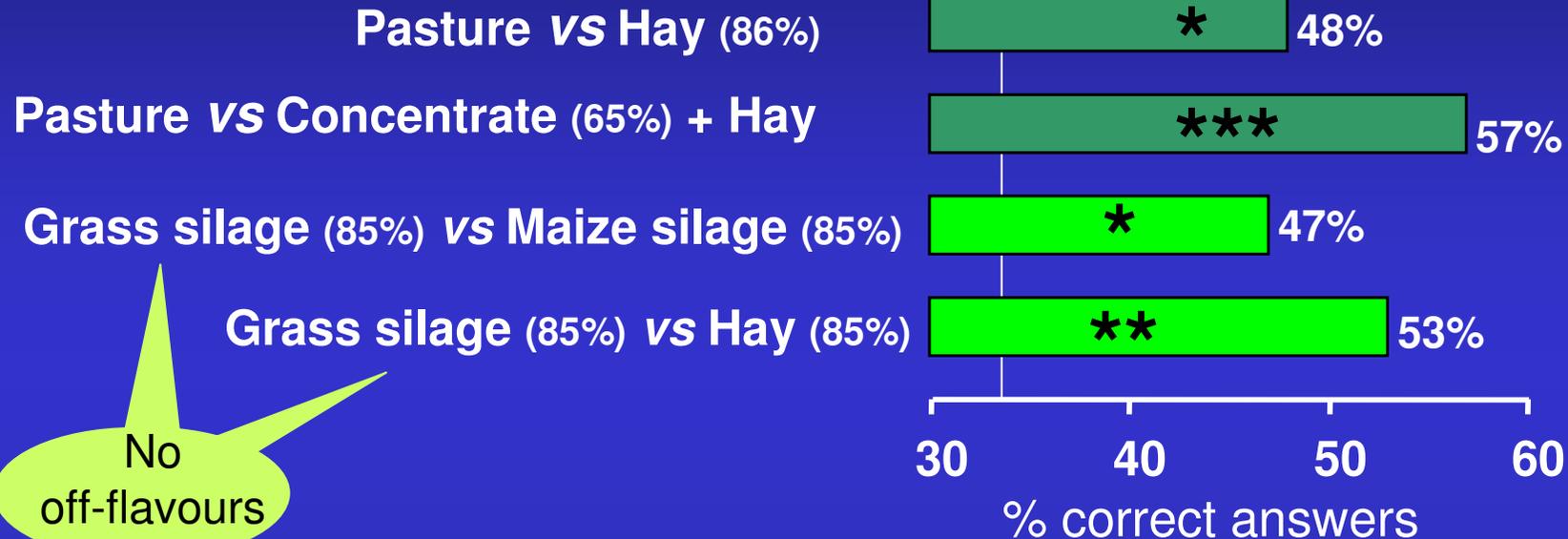
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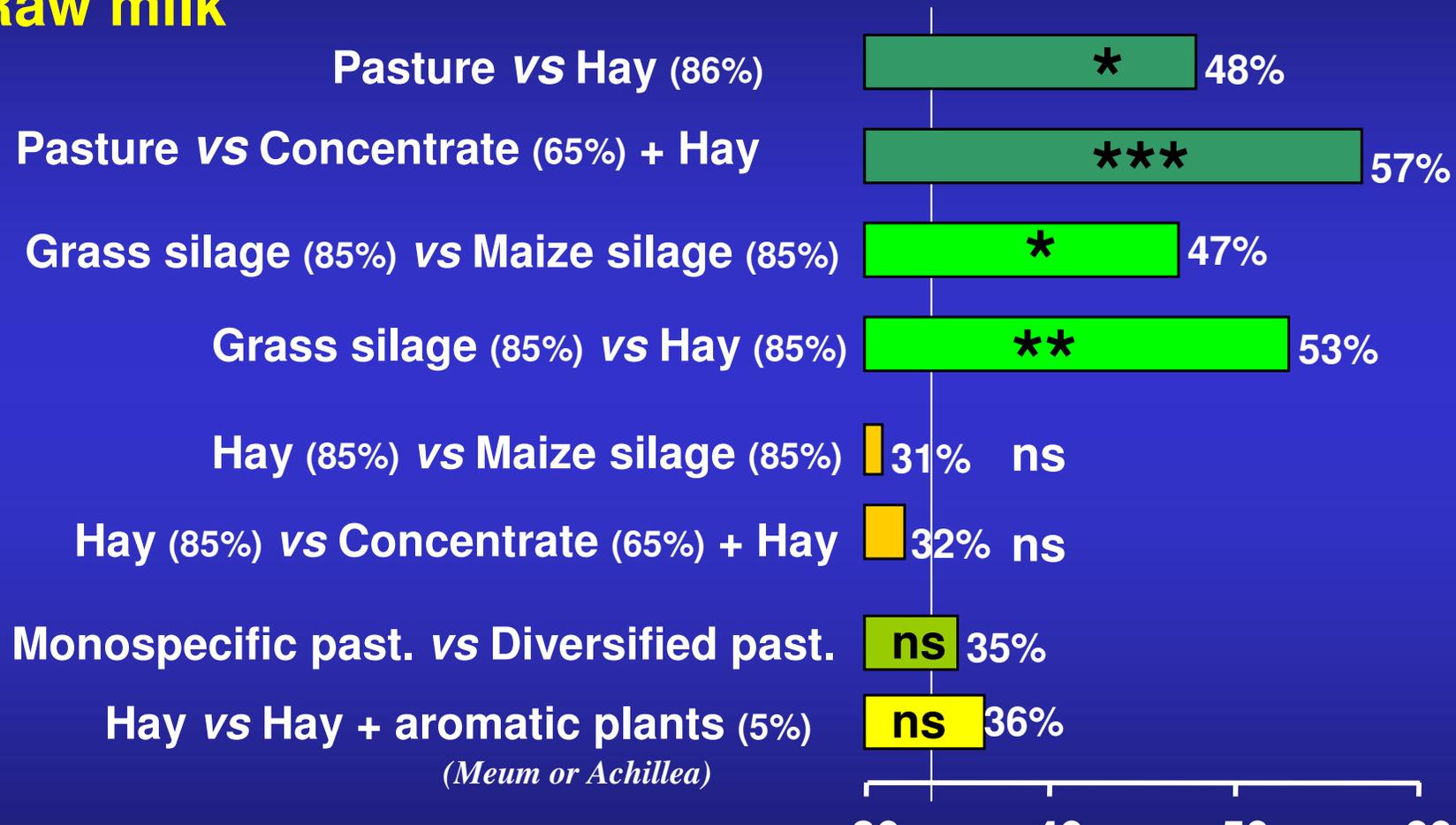
Grass silage and milk off-flavours:

- Milk can gain off-flavours (“feed” flavours) from poor-quality silages
- Off-flavours transmitted rapidly, both through respiratory and digestive routes
- Risk factors at farm level: - poor silage quality and poor air quality in the barn
- feeding silage just before milking

Shipe et al., 1962; Urbach, 1990; Mouchili et al., 2004, 2005; Kalac, 2011

Sensory properties of milk according to the nature of the forage

Raw milk



Terpenes from aromatic plants transferred to milk but under the threshold concentration for the perception of the flavour in milk (0.1-1 $\mu\text{L/L}$)

Milk sensory properties

Cheese sensory properties

Forage and cheese sensory properties

General trends

Maize silage Hay Grass Silage Pasture

Colour

→ β carotene in milk

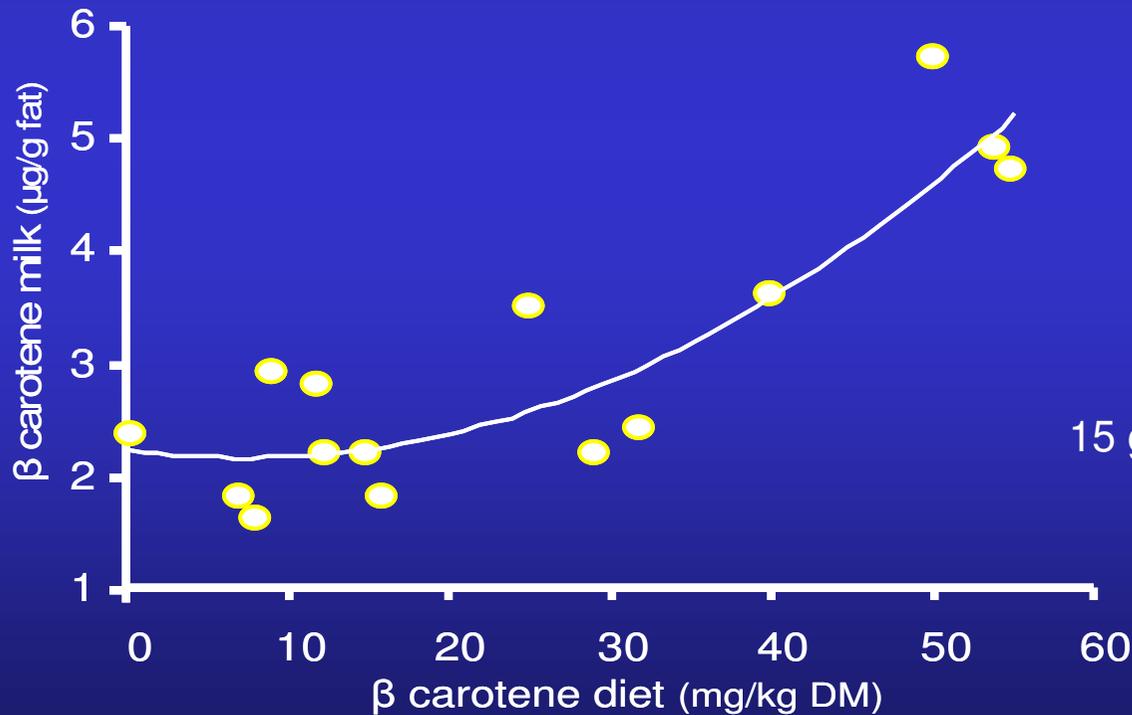
Yellow colour

-

+

++

+++



15 groups of cows

Nozière et al., 2006



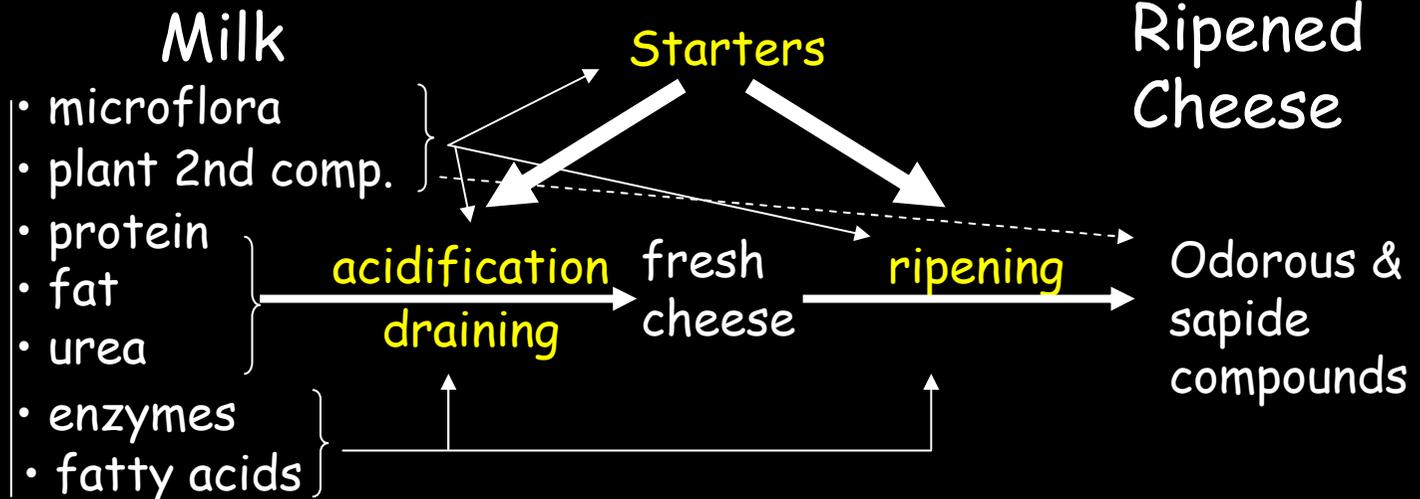
Forage and cheese sensory properties

General trends

	Maize silage	Hay	Grass Silage	Pasture
Colour	→ β carotene in milk			
Yellow colour	-	+	++	+++
Texture	→ Lower melting point of unsaturated fatty acids		→ Fat globule size → Proteolysis	
Firm Texture	+	-	-	--
Flavour	→ ???			
Diversity / intensity	-	+/-	+/-	+ / +++

Hypothesis

Forages (diet x animal) →



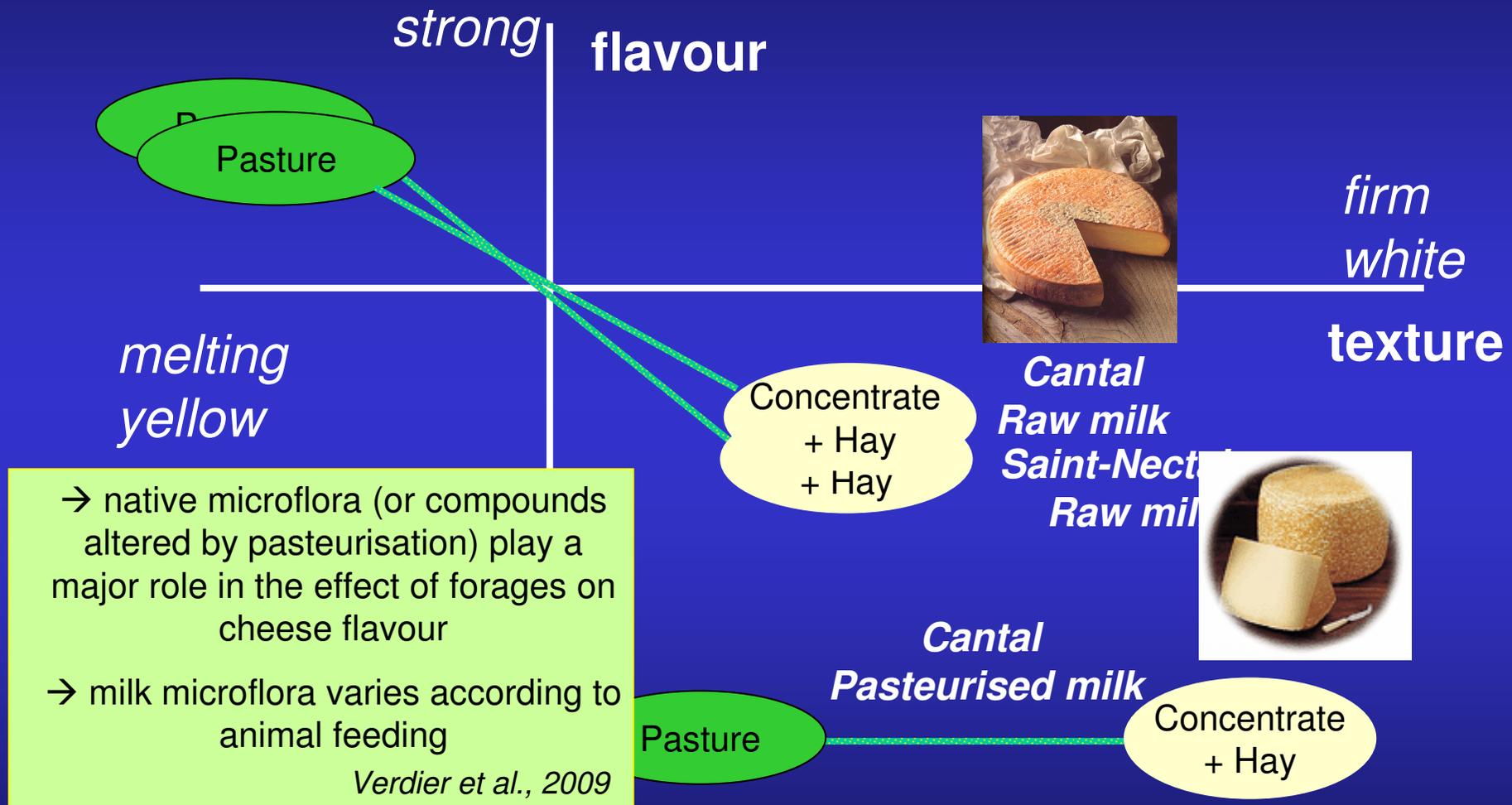
Forage and cheese sensory properties

General trends

	Maize silage	Hay	Grass Silage	Pasture
Colour				
Yellow colour	-	+	++	+++
	→ β carotene in milk			
Texture				
Firm Texture	+	-	-	--
	→ Lower melting point of unsaturated fatty acids		→ Fat globule size → Proteolysis	
Flavour				
Diversity / intensity	-	+/-	+/-	+ / +++
	→ ???			
Aspect				
Rind development		+		-
	→ Inhibition of rind microflora by exsudated fat?			

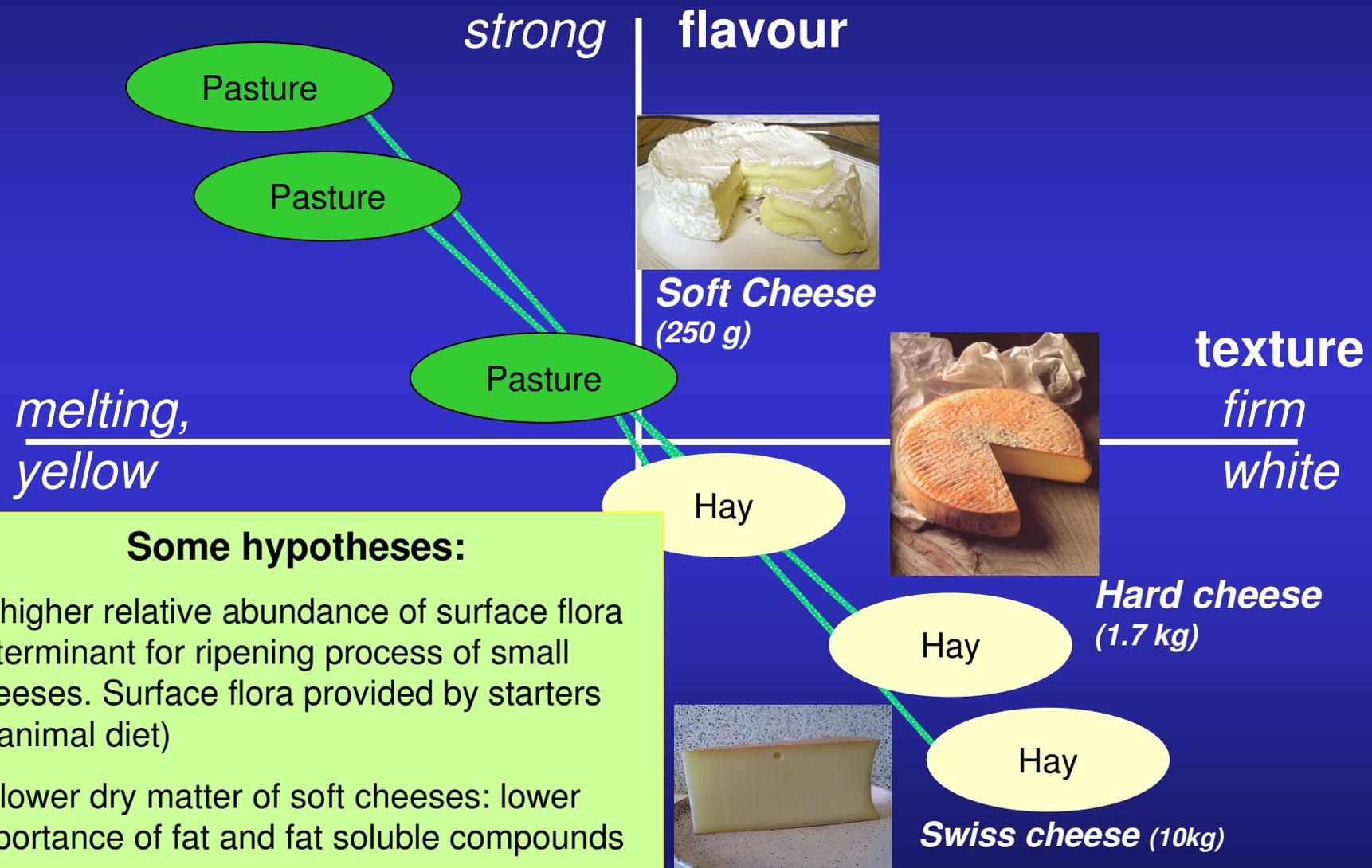
Many interactions with the process...

Forage and cheese sensory properties interaction with pasteurisation



specifications process / milk production conditions?

Forage and cheese sensory properties interaction with cheese model



Some hypotheses:

- higher relative abundance of surface flora determinant for ripening process of small cheeses. Surface flora provided by starters (≠ animal diet)
- lower dry matter of soft cheeses: lower importance of fat and fat soluble compounds
- other hypothesis linked to process

Forage and cheese sensory properties (interaction with cheese model)



Other interactions reported :

- Cheese model (Hurtaud et al., 2006; Verdier-Metz et al., 2005)
- Ripening time (Agabriel et al., 2004; Coppa et al., 2011)
- Milk fat standardization (Coulon et al., 2004)
- Acidification rate (starters used) (Martin et al., 1995; Coulon et al., 2004)

soft



Hay

Hard cheese
(1.7 kg)

Hay

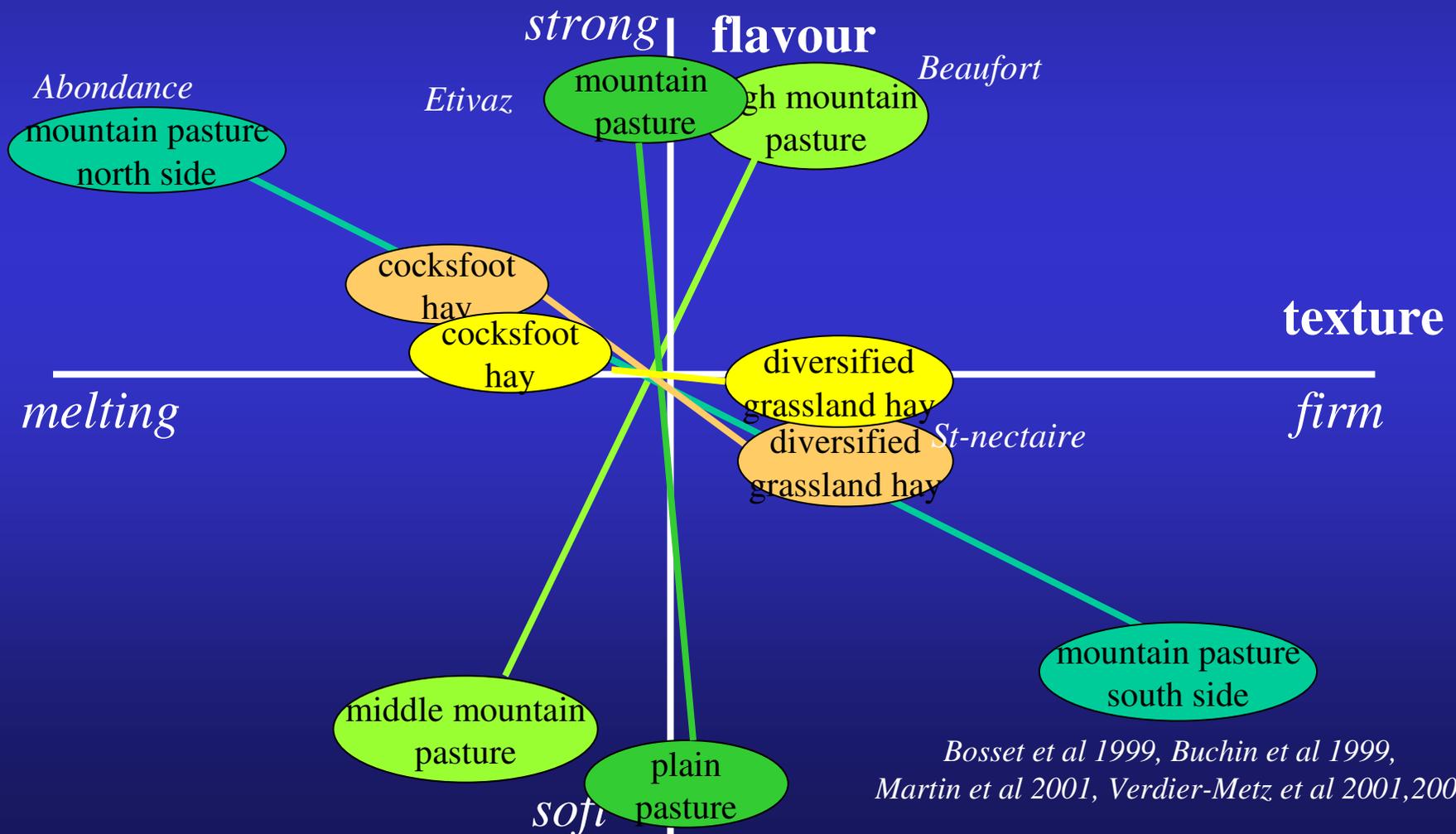
Swiss cheese (10kg)

Verdier et al., 2009

Botanical composition of forages and cheese sensory characteristics

On-farm conditions

- ▶ Cheese sensory properties are modified when the botanical composition of the forage changes



Botanical composition of forages and cheese sensory characteristics

On-farm conditions

- ▶ Cheese sensory properties are modified when the botanical composition of the pasture changes

Grasslands from lowland
rich grasses and legumes



Intense taste and cabbage
or pungent flavours

Abundance



associations

Bugaud et al., 2001;
Martin et al 2005

Grasslands rich in a wide
variety of highland dicot.



Fruit, hazelnut and
cooked milk flavours

- ▶ Meta-analysis of a database with 100 cheeses: similar trends within experiments but impossible to find specific plants associated with individual aromas

Farruggia et al., 2009

Experimental conditions

- ▶ the effect of the biodiversity on cheese flavour is weaker and varies during summer.

Coppa et al., 2011

How can we explain the effect of the botanical composition of grasslands on cheese?

▶ Polyunsaturated FA?

Collomb et al., 2001

▶ Activity of plasmin?

Bugaud et al., 2001

▶ Terpenes from aromatic plants proposed to explain the effect of pasture botanical composition

Bugaud et al., 2001

* inhibitors of the production of volatile compounds by microorganisms?

Essential oil added in milk	0	+ 0.1 $\mu\text{g/L}$	+ 1 $\mu\text{g/L}$	+ 3 $\mu\text{g/L}$
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	0	+ 0.1 $\mu\text{g/L}$	+ 1 $\mu\text{g/L}$	+ 3 $\mu\text{g/L}$
Swiss cheese				
Microbial counts				
Volatile Compounds (other than added)			Marginal modifications	
Hard Cheese				
Volatile Compounds (other than added)			Marginal modifications	
Sensory Properties (0-7)				
'Thymus' Aroma	0.1	0.1	/	3.1

Terpenes = markers of other plant secondary compounds ?

Buchin et al., 2006

Tornambé et al., 2008

Conclusions

Significant effects of forage on milk and cheese sensory properties

Confirm the empirical observations of the farmhouse cheesemakers

Effects of diets < or << effects of technological parameters

*Good control of technological factors is necessary
to study the effect of diets*

Interactions identified with different aspects of the process

Some technologies better suited than others to reveal the effect of diets

We can partly explain the effects

*Due to the presence in milk and cheeses of molecules directly transferred
from diet or produced by the animals*

Conclusions

Objective references for cheesemakers (PDO, ...)

- *Refine the understanding of the 'link to terroir'*
- *Develop appropriate specifications so that cheeses reflect best the uniqueness and diversity of the land where they are produced*

Interest of grass (pasture from biodiverse grasslands) for the sensory quality of cheese

Before making decision, we have to consider:

- *other dimensions of the quality (safety, nutritional, image...)*
 - *Impacts on the sustainability of farmers
(economy, environment and social)*

Thank you for your attention

