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► **To cite this version:**

Bruno Martin, Anne A. Farruggia. Terroir : relationship between land, management and quality of dairy products. Bioforsk Konferansen, Feb 2013, Hamar, Norway. pp.24. hal-02805876

HAL Id: hal-02805876

<https://hal.inrae.fr/hal-02805876>

Submitted on 6 Jun 2020

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Terroir: relationship between land, management and quality of dairy products.

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Context

Erosion in consumer confidence in dairy products

Safety, environmental and nutritional issues

**Increasing demand about information
concerning animal management**

Positive image of grass based diets

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

*Animal characteristics and feeding are part of the
« terroir »*

Link between terroir and cheese sensory quality?

Context

Why?

To answer the questions of PDO cheese producers

Link to “terroir”

Choice of specifications for milk production

In France: 46 PDO dairy products, 10% of the milk (cow and goat) and 40 % for ewe milk



Comté



Cantal



Roquefort



Reblochon



St-Nectaire

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

Mountain : 25% of agricultural lands, 20% of the dairy farmers, 14%
of the milk, higher production costs (+50 €/1000L)

Animal characteristics and feeding
→ sensory properties of dairy products

So far:

Many empirical observations but few experimental works

What is a PDO Product?

- Definition of PDO :« a product that originate from a territory and whose characteristics are linked mainly to the geographical environment including human and natural factors »»
EU regulation n°510/2006

↳ « *typicity* » (*specific characteristics*) linked to terroir

- Definition of terroir : **defined geographical area** where a human community built during its **history** a **collective know-how** for production based on a **system of interactions** between physical, biological and human factors

↳ *some conditions of milk production are linked to terroir*

Source : Casabianca et al., 2011



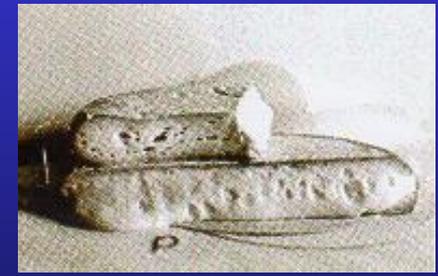
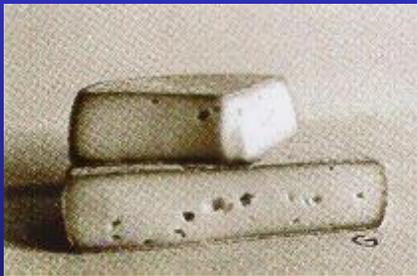
The sensory characteristics of dairy products first depend on cheesemaking process (collective know-how)!

1 raw material = huge diversity of dairy products

The milk characteristics (local physical and biological factors) also 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

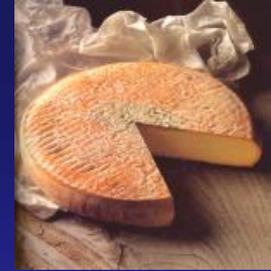
**Could these differences be linked
to terroir components ?**

**A focus on cattle cheese
sensory properties linked to :**

Animal characteristics

Animal feeding

Sensory characteristics of Saint Nectaire cheeses according to the breed of cows



Holstein



Montbéliarde



Fat in dry, %

52,7

52,9

Yellow index

31,4

30,4

Sensory panel (/10)

Melting texture

3,0

**

4,2

Intense flavour

5.0

*

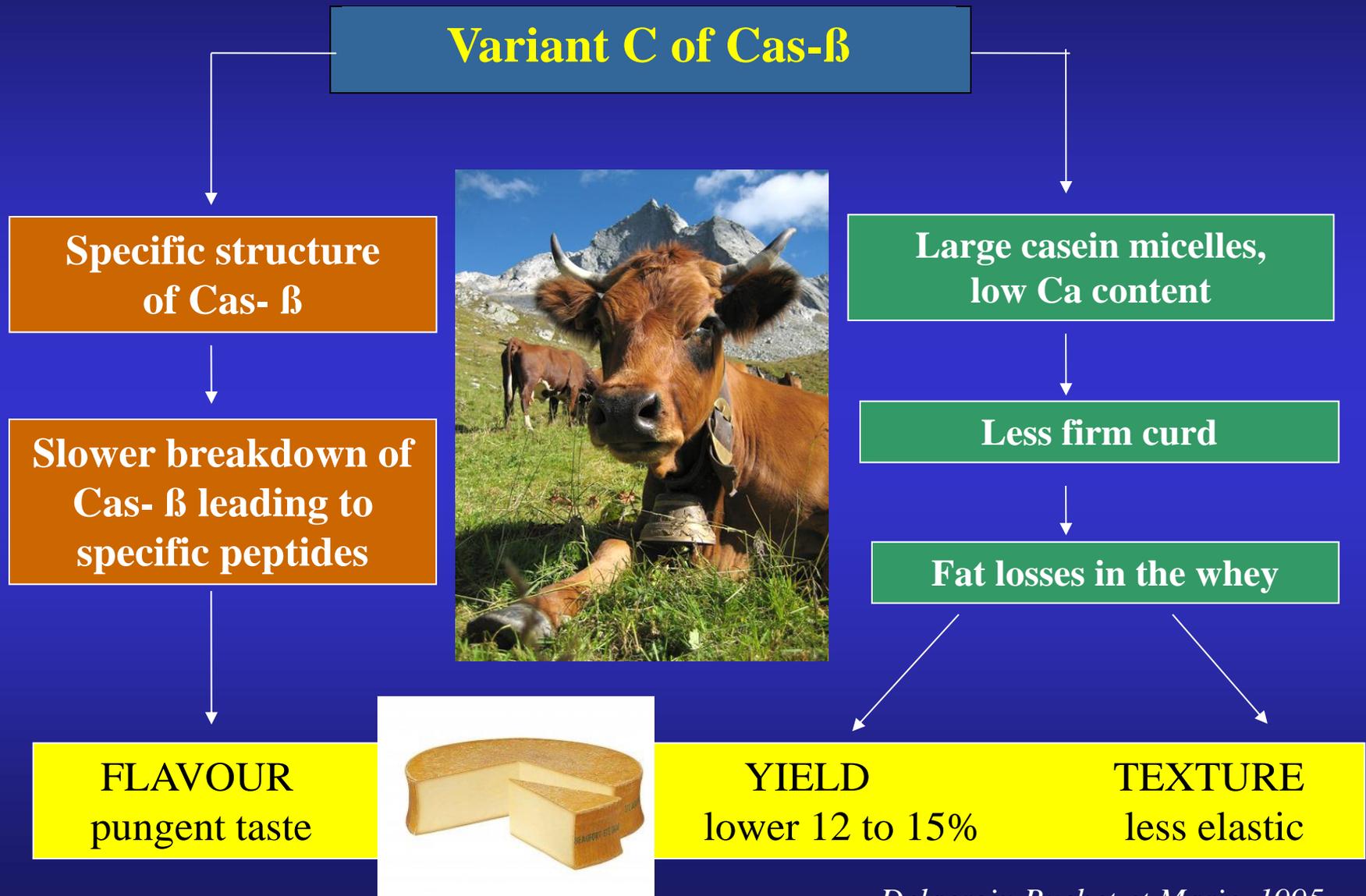
5.6

Verdier-Metz et al., 1995

Results confirmed with Cantal cheeses

Martin et al., 2009

Variant C of β -Cas from Tarentaise cows



Animal characteristics

Animal feeding

Forage and cheese sensory properties

General trends

Maize silage Hay Grass Silage Pasture

→ β carotene in milk

Colour

Yellow colour

-

+

++

+++

Texture

Firm texture

→ Lower melting point of
unsaturated fatty acids

→ Fat globule size
→ Proteolysis

+

-

-

--

Forage and cheese sensory properties

General trends

Maize silage Hay Grass Silage Pasture

→ β carotene in milk

Colour

Yellow colour

-

+

++

+++

Texture

Firm texture

+

-

-

--

Flavour

→ ???

Diversity / intensity

-

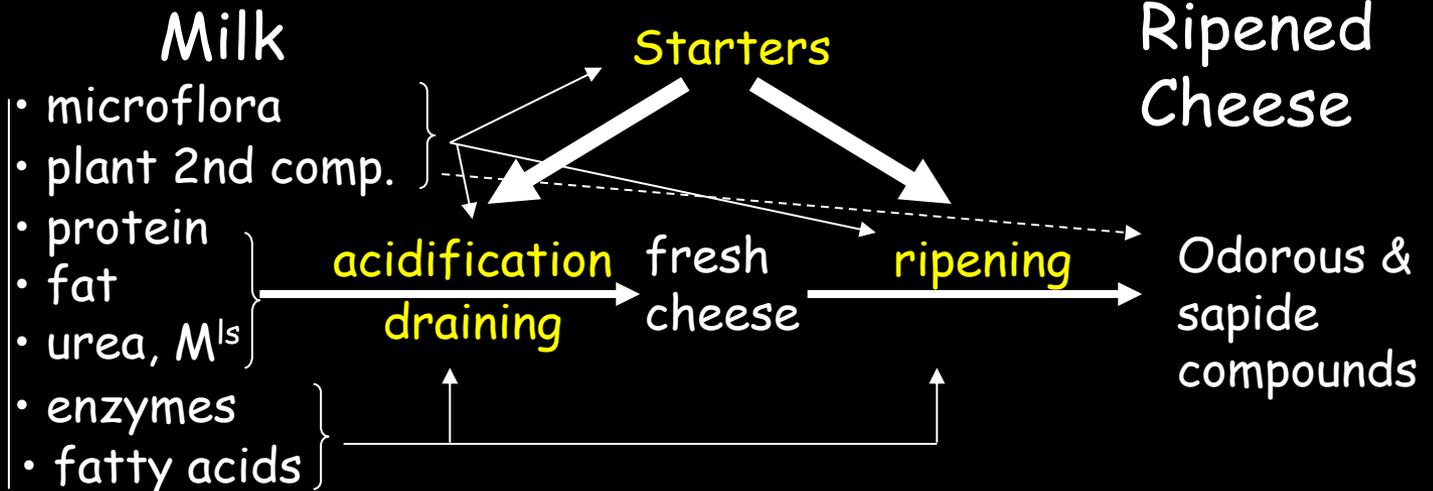
+/-

+/-

+ / +++

Hypothesis

Forages (diet x animal) →



Forage and cheese sensory properties

General trends

Maize silage Hay Grass Silage Pasture

→ β carotene in milk

Colour

Yellow colour

-

+

++

+++

Texture

→ Lower melting point of unsaturated fatty acids

→ Fat globule size
→ Proteolysis

Firm Texture

+

-

-

--

Flavour

→ ???

Diversity / intensity

-

+/-

+/-

+ / +++

Aspect

Rind development

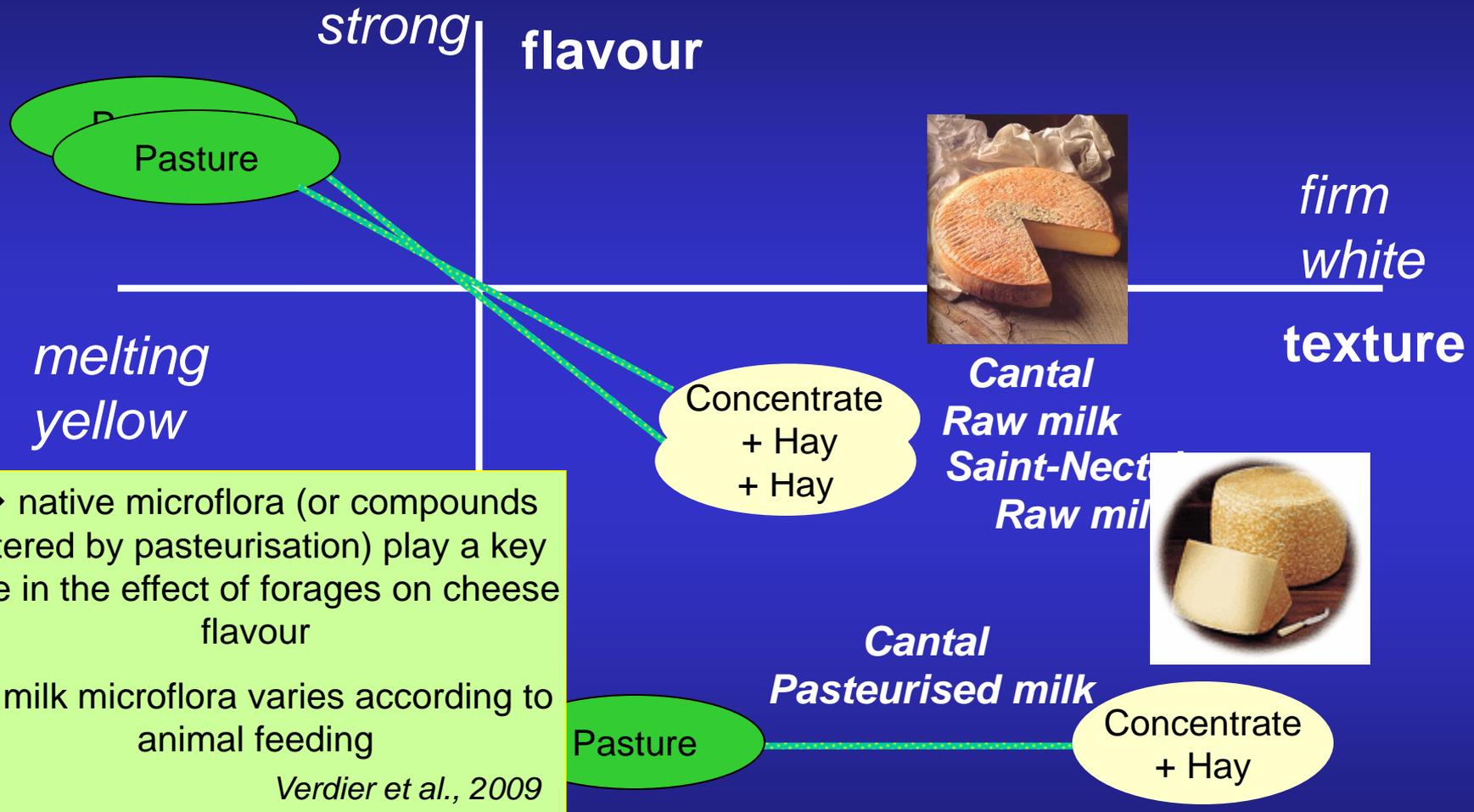
→ Inhibition of rind microflora by exsudated fat?

+

-

Many interactions with the process...

Forage and cheese sensory properties interaction with pasteurisation



→ native microflora (or compounds altered by pasteurisation) play a key role in the effect of forages on cheese flavour

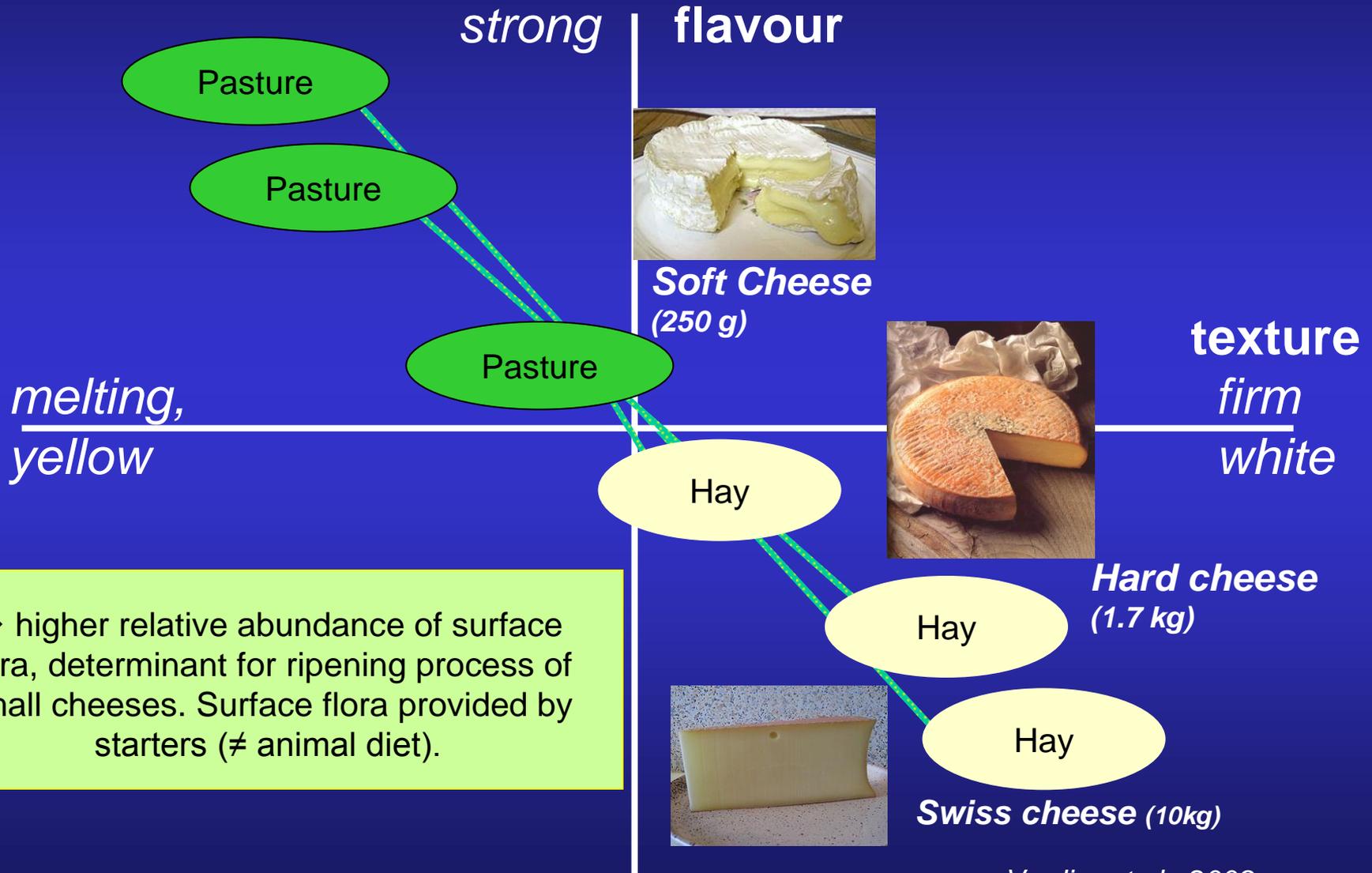
→ milk microflora varies according to animal feeding

Verdier et al., 2009



Link to terroir disrupted by pasteurisation?

Forage and cheese sensory properties interaction with cheese model



→ higher relative abundance of surface flora, determinant for ripening process of small cheeses. Surface flora provided by starters (≠ animal diet).

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)



Botanical composition of forages and cheese sensory characteristics

On-farm conditions

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

*Bosset et al 1999, Buchin et al 1999,
Martin et al 2001, Verdier-Metz et al 2001,2002*

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 50 cheeses: similar trends within experiments but impossible to find specific species associated with individual aromas

Farruggia et al., 2009

Experimental conditions

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

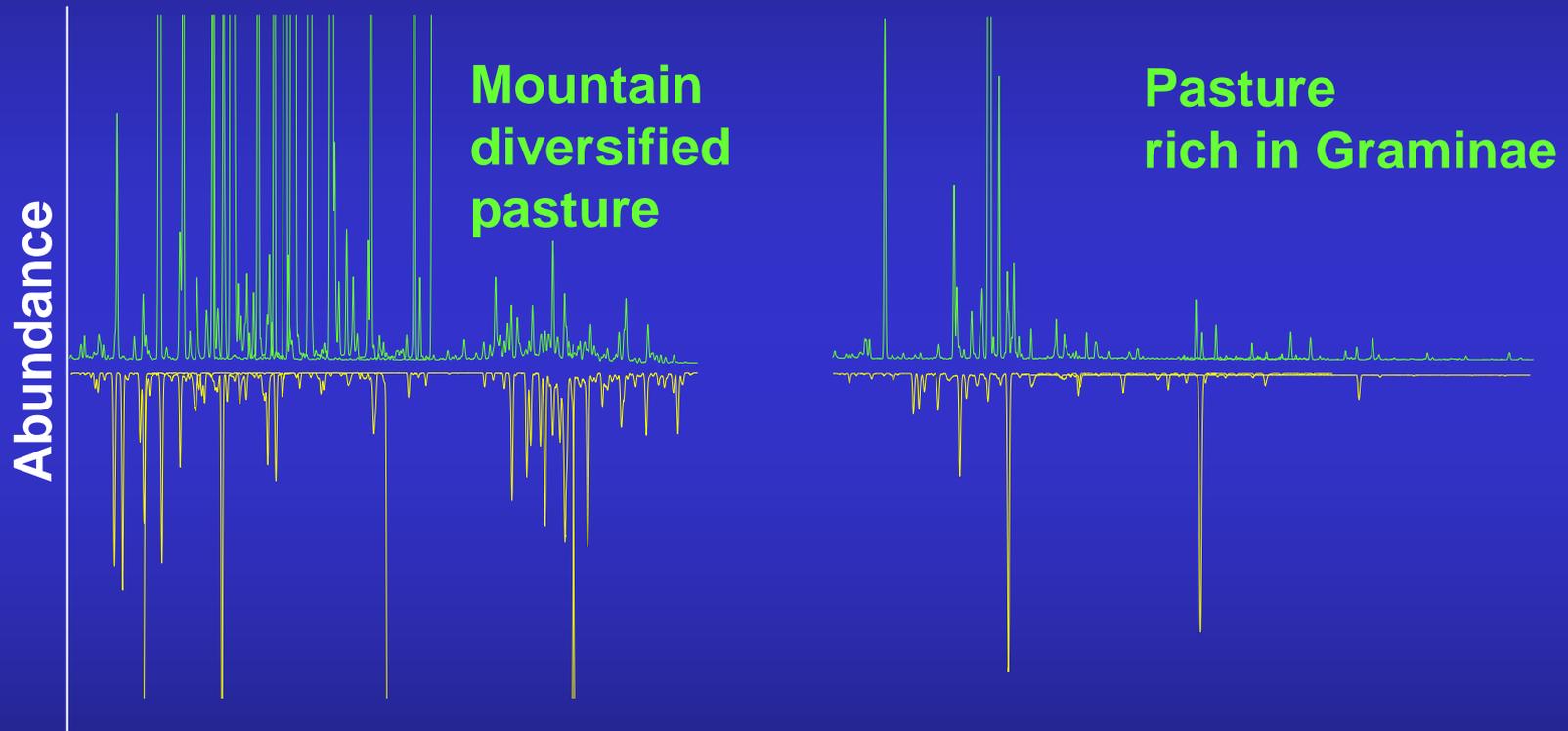
Coppa et al., 2011

Terpenes :

- ✓ Large family of compounds
- ✓ Originate from plants
- ✓ Odorous compounds when concentrated
- ✓ In forages, nature and composition of terpenes = f(botanical composition)
- ✓ Identified in dairy products
- ✓ Transferred rapidly from plants to milk

Terpenes in **grass** and in **cheeses** (Abundance cheese)

Terpenes composition in grass



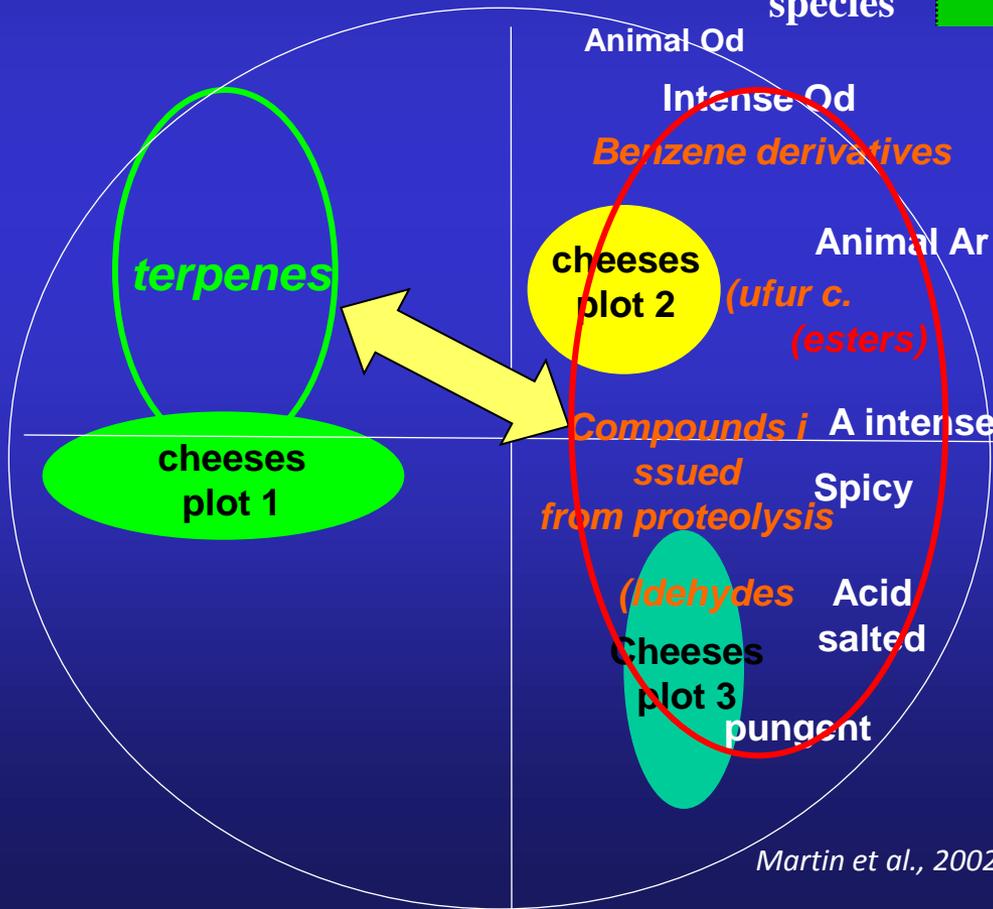
Terpenes composition in cheeses

Botanical composition of forages and sensory characteristics of Beaufort cheese



Comparison of cheeses made on 3 different plots of the alpine pasture
Axe 2, 24%

	Plot 1	Plot 2	Plot 3
altitude	2200 m	2050 m	2500 m
Grasses	38 % <i>Festuca rub.</i>	47 % <i>Agrostis cap.</i>	30 % <i>Nardus str.</i>
Aromatic species	++	=	-



✓ no direct effect of terpenes on odours and aromas

✓ effect of terpenes on the activity of the microbiological ecosystem of cheese?

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

► 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 μg/L	+ 1 μg/L	+ 3 μg/L
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	0	+ 0.1 μg/L	+ 1 μg/L	+ 3 μg/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 environmental factor of the terroir on cheese sensory properties

Confirm the empirical observations of the farmhouse cheesemakers

Effects < or << effects of cheesemaking process

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

Interactions identified with different aspects of the process

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

We can only 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 terroir where they are produced*

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

Interest to preserve the biodiversity for the cheese quality

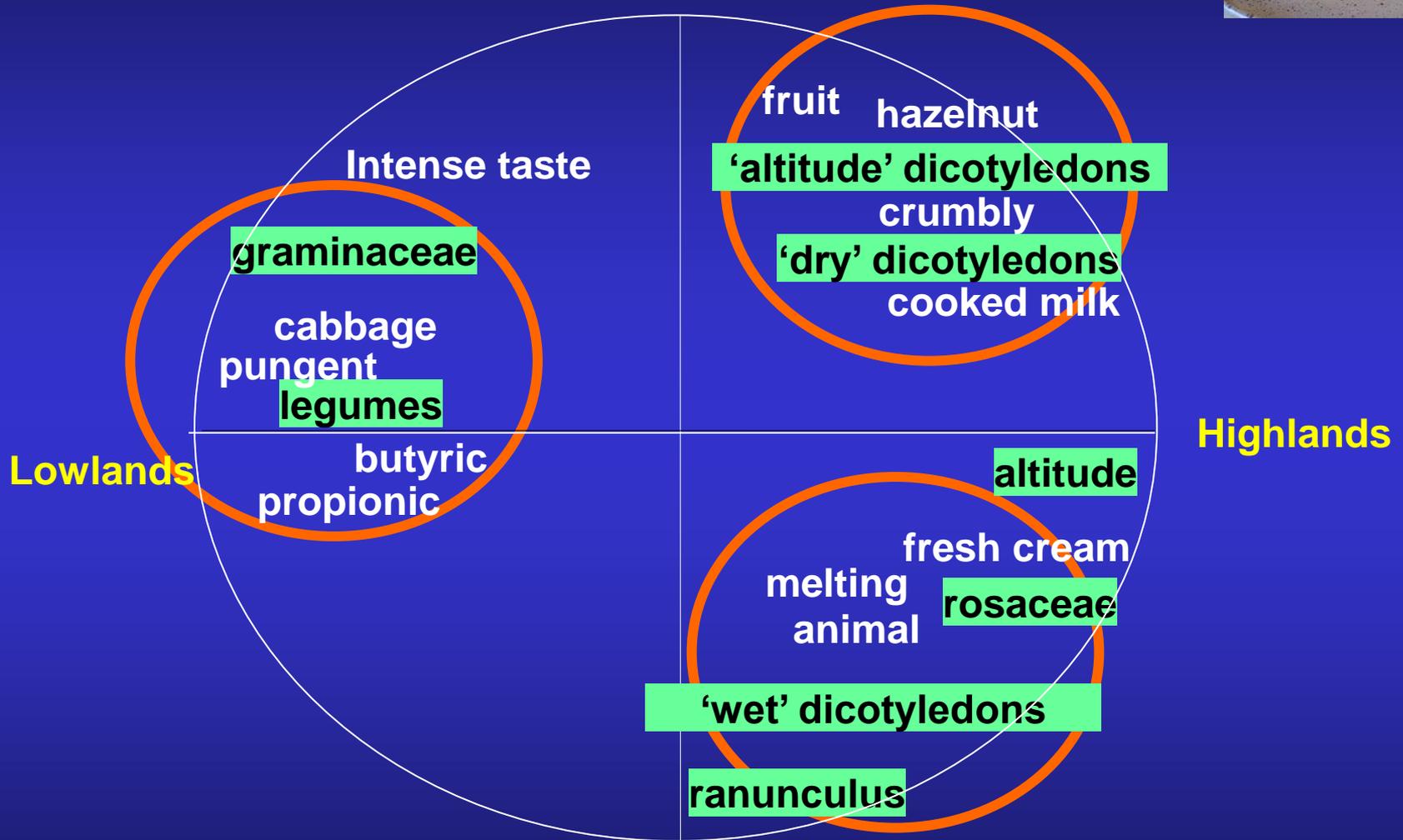
Before making decision, we have to consider:

- *Other aspects of the quality (safety, nutrition, image...)*
- *Impacts on the sustainability of farmers
(economy, environment and social)*

Thank you for your attention



Associations between Abundance cheese sensory properties and pasture characteristics



Axis 1 & 2 of a Principal Component Analysis.

Pasture characteristics: active variables

Cheese characteristics: illustrative variables