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The Science of Artisan Cheese

19th -20th August 2014

North Cadbury Court, Somerset

How cow characteristics and management influence the sensory properties of milk and cheese?

B Martin¹

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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

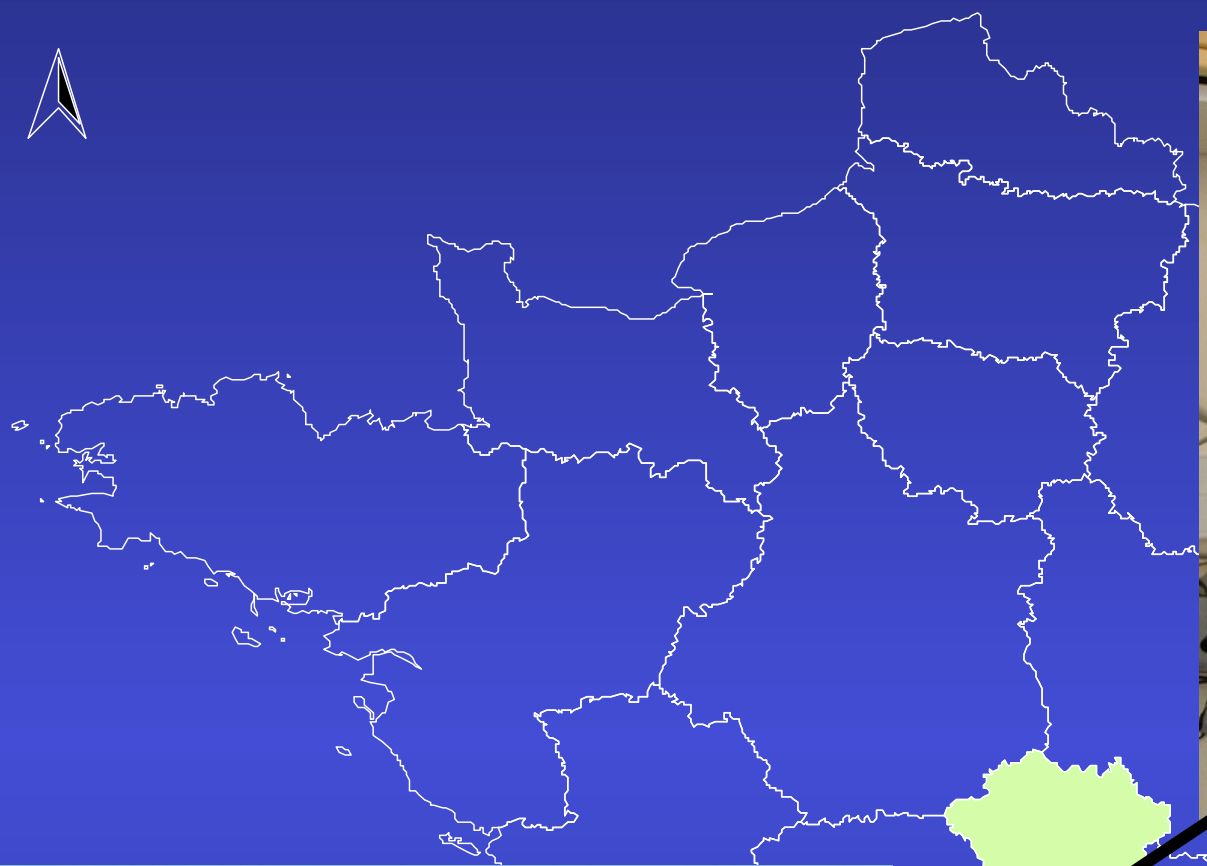
Mountain : 25% of agricultural lands, 20% of the dairy farmers, 14%
of the milk, higher production costs (+50 €/1000L)

Animal characteristics and feeding
→ sensory properties of dairy products

So far:

Many empirical observations but few experimental works

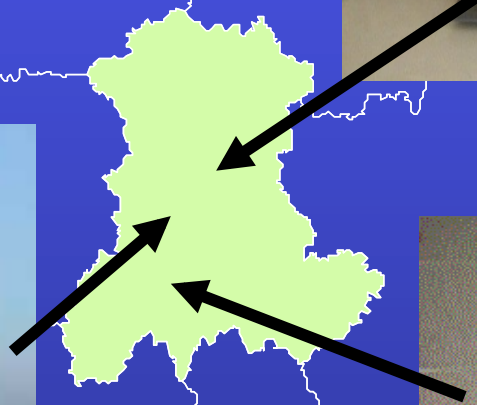
The INRA Auvergne facilities



INRA Theix
Herbivore Research Unit
Animal Product Quality Unit
Laboratories



INRA Marcenat
Experimental farm



INRA Aurillac
Cheese Research Unit
Pilot Dairy plant & Lab.

France

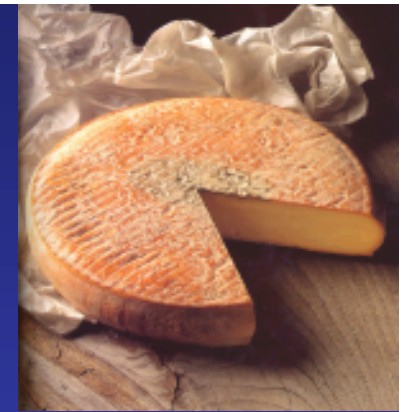
**A focus on cattle milk and cheese
sensory properties linked to :**

Animal genetics

Animal feeding

Milk - Cheese

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



Holstein



Montbéliarde



vs

Fat in dry, %
Yellow index

52,7
31,4

52,9
30,4

Sensory panel (/10)

Melting texture

3,0

**

4,2

Intense flavour

5.0

*

5.6

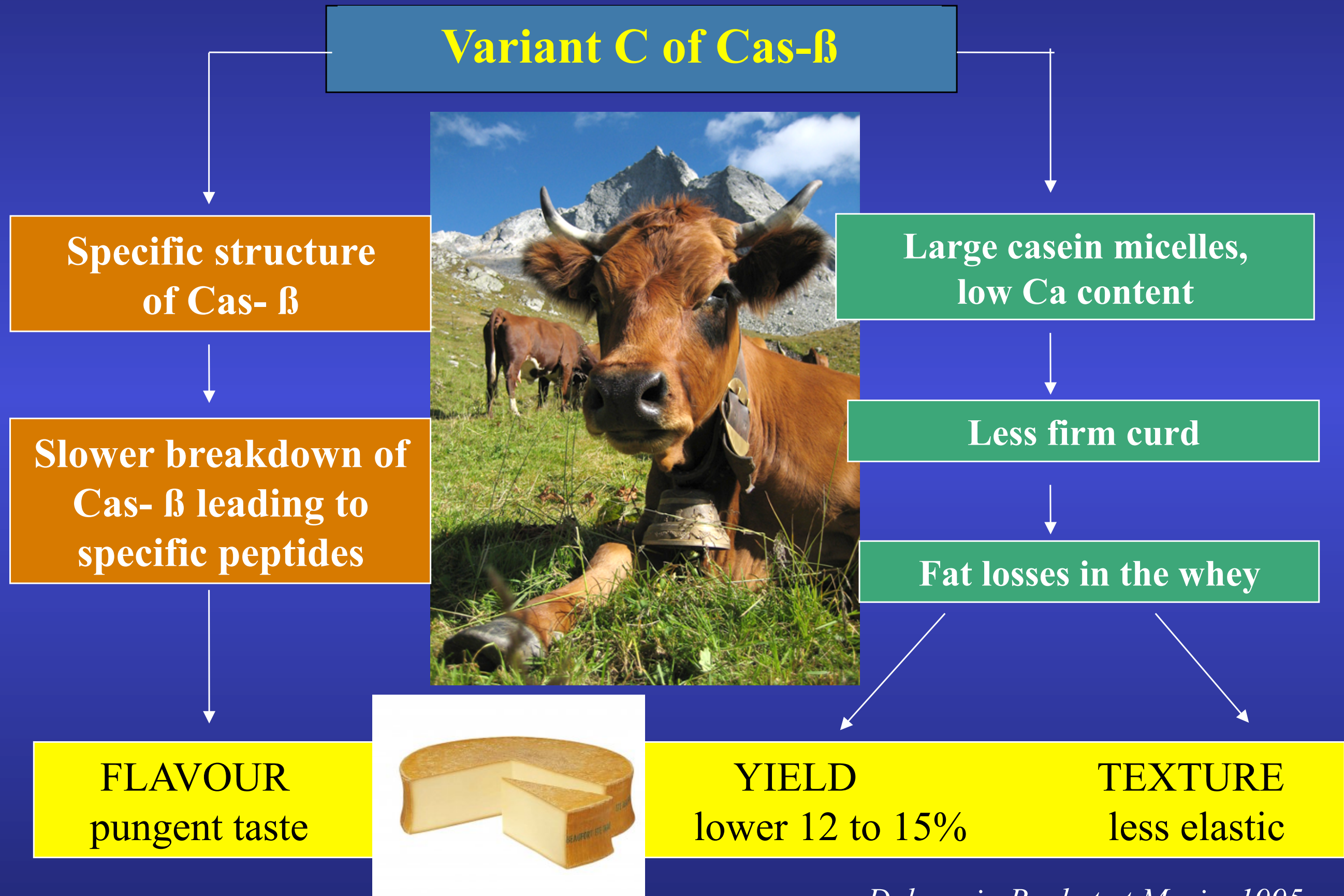
Verdier-Metz et al., 1995



Results confirmed with Cantal cheeses

Martin et al., 2009

Variant C of β -Cas from Tarentaise cows



Delacroix-Buchet et Marie, 1995

Variant I of κ -Cas from Salers cows



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

Animal genetics

Animal feeding

Milk - Cheese

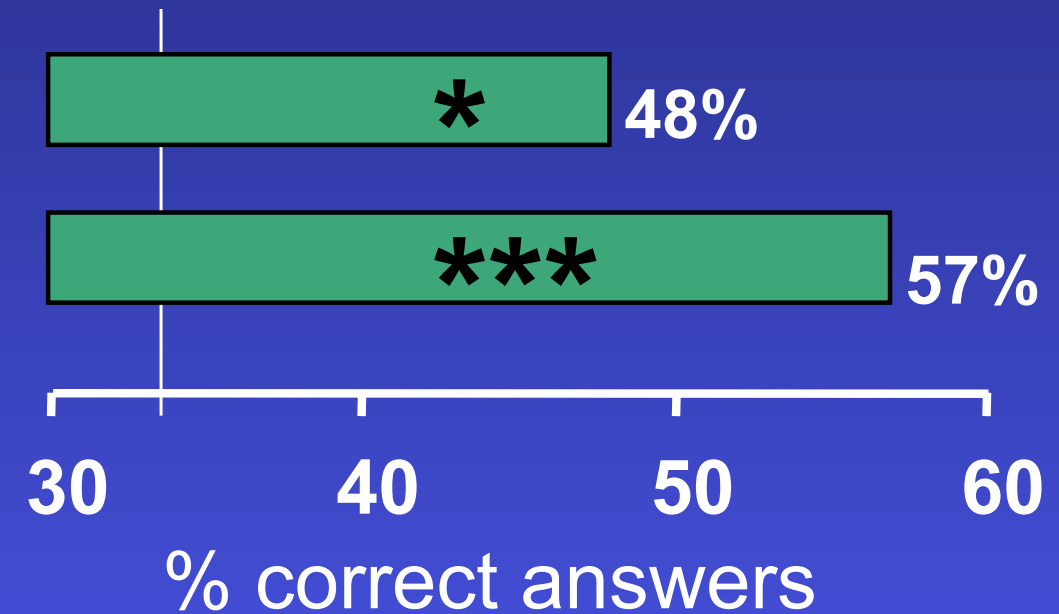
Sensory properties of milk according to the nature of the forage

Raw milk

Pasture vs Hay (86%)

Pasture vs Concentrate (65%) + Hay

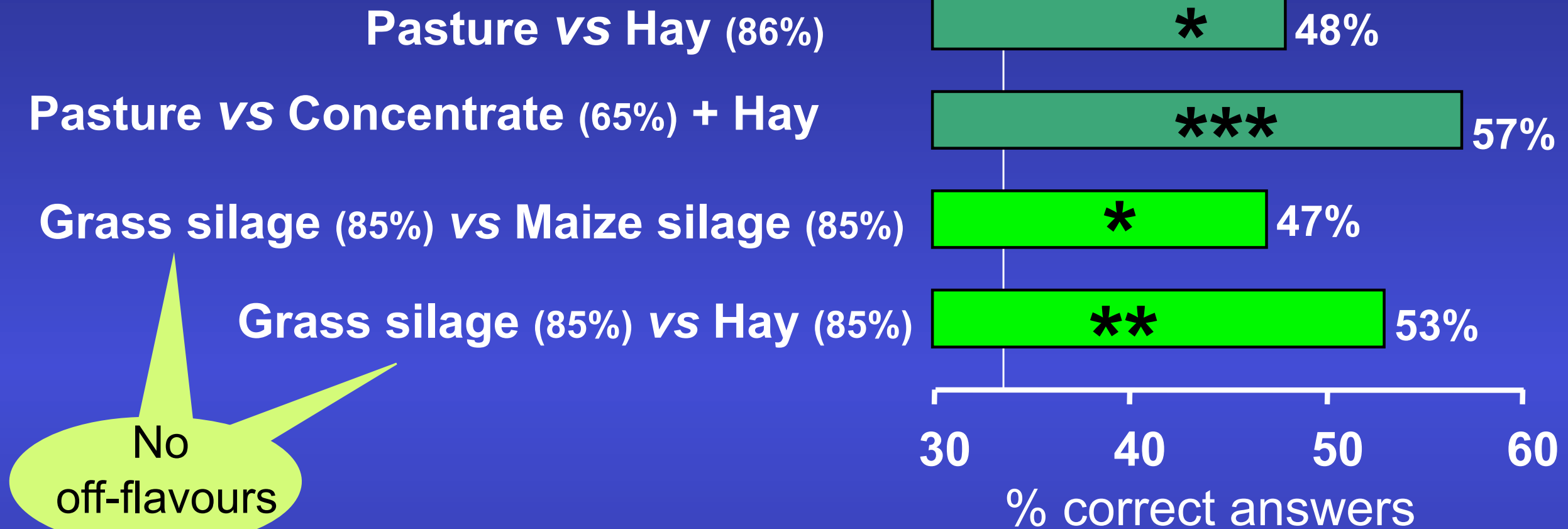
More intense** and barn odour**



Results obtained by Triangle tests, in red light.
Dubroeuq et al., 2002

Sensory properties of milk according to the nature of the forage

Raw milk



Results obtained by Triangle tests, in red light.
Dubroeucq et al., 2002

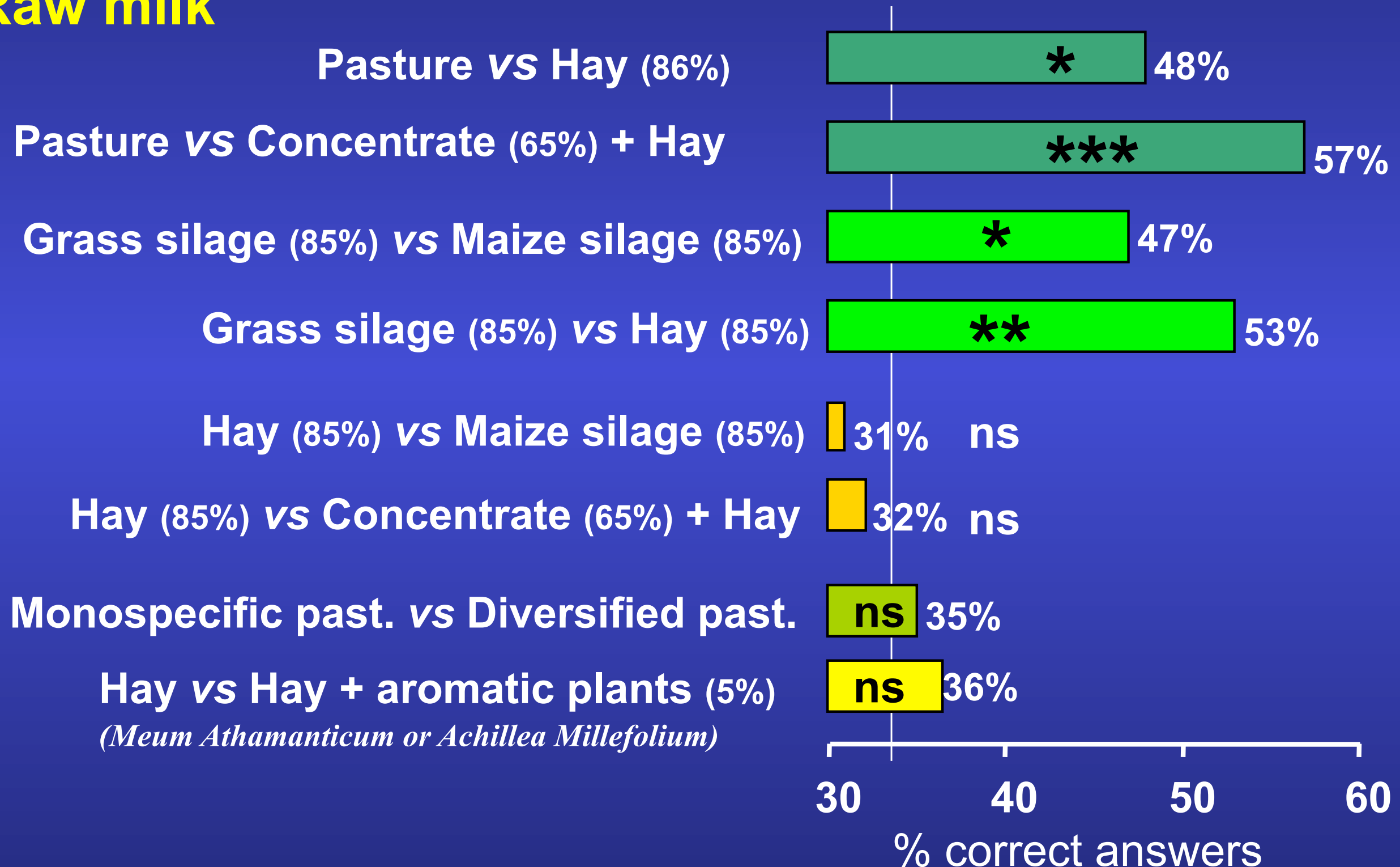
Grass silage and milk off-flavours:

- 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



Results obtained by Triangle tests, in red light.
Dubroeuq et al., 2002 & Martin et al., unpublished

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

→ Proteolysis

Firm texture

+

-

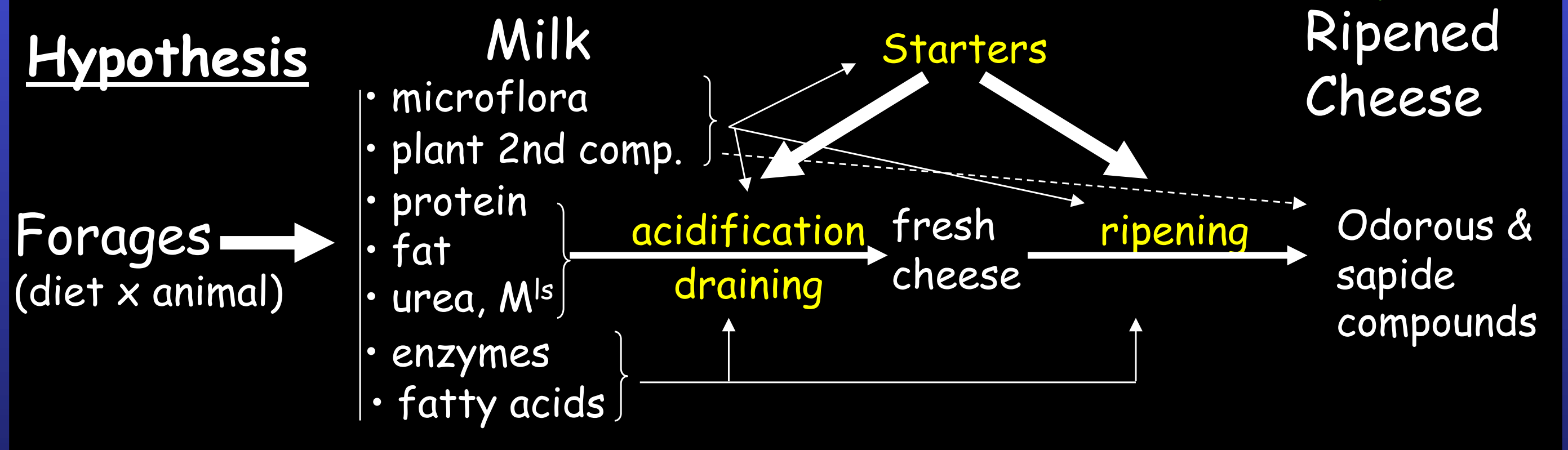
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Forage and cheese sensory properties

General trends

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



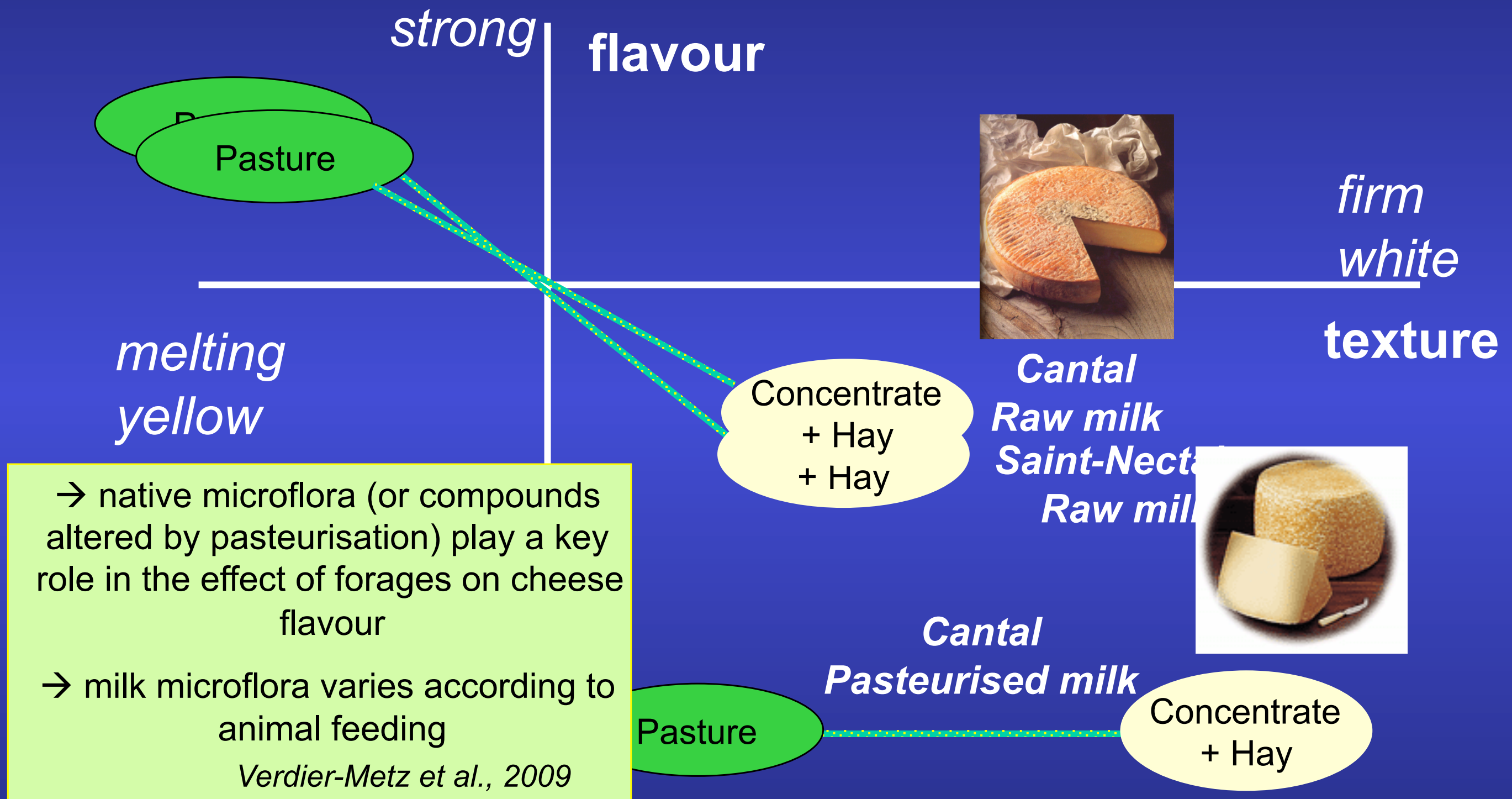
Forage and cheese sensory properties

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		→ Proteolysis	
Flavour				
Diversity / intensity	-	+/-	+/-	+ / +++
	→ ???			

Many interactions with the process...

Forage and cheese sensory properties interaction with pasteurisation



Link to terroir disrupted by pasteurisation?

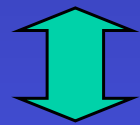
Botanical composition of forages and cheese sensory characteristics

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

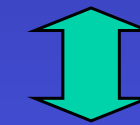
Abundance cheese



associations

Bugaud et al., 2001; Martin et al 2005

Grasslands rich in a wide variety of highland dicot.



Fruit, hazelnut and cooked milk flavours

Experimental conditions

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

Coppa et al., 2011

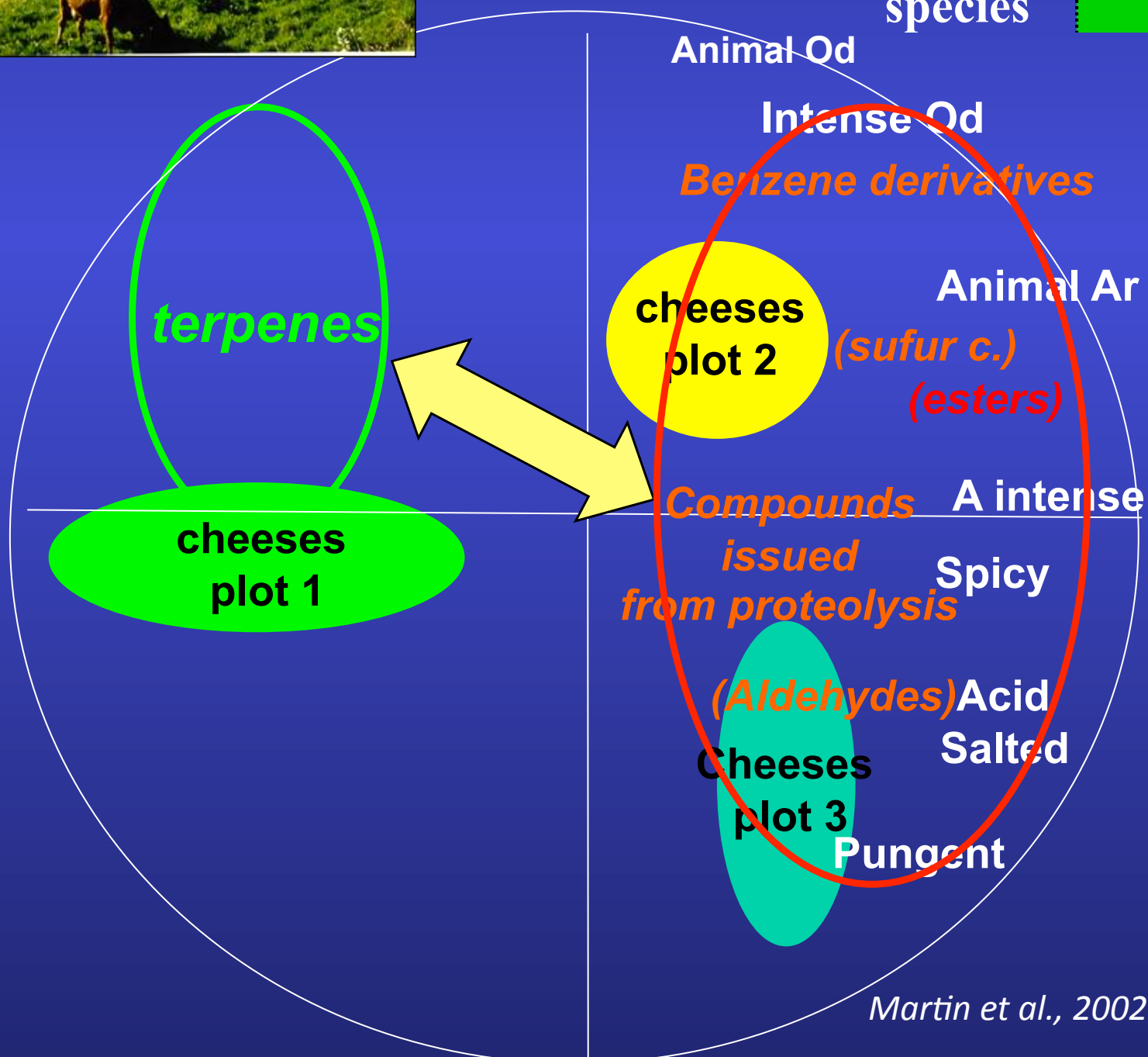


Botanical composition of forages and sensory characteristics of Beaufort cheese



Comparison of cheeses made on 3 different plots of the alpine pasture

	Plot 1	Plot 2	Plot 3
altitude	2200 m	2050 m	2500 m
Grasses	38 % <i>Festuca rubra</i>	47 % <i>Agrostis capilaris</i>	30 % <i>Nardus stricta</i>
Aromatic species	++	=	-



✓ indirect effect of terpenes on the activity of the microbial ecosystem of cheese?

Terpenes :

✓ Large family of compounds

✓ Originate from plants

✓ Odorous compounds when concentrated

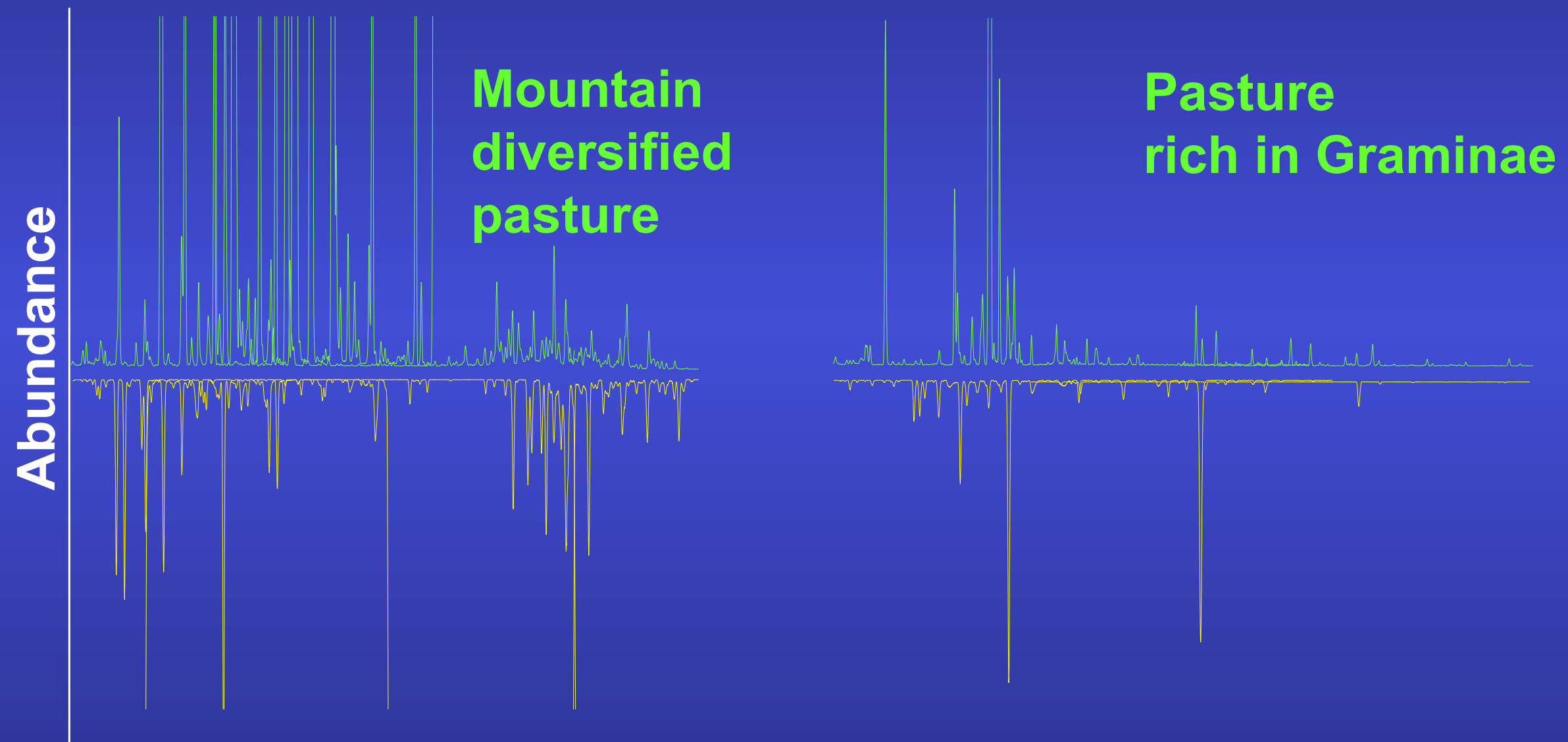
✓ In forages, nature and composition of terpenes
= f(botanical composition, phenological stage)

✓ Identified in milk and cheese

✓ Transferred rapidly from plants to milk

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

Terpenes composition in grass



Terpenes composition in cheeses

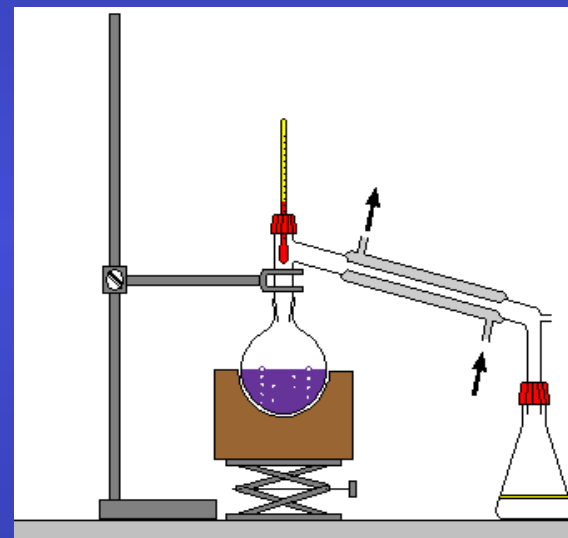
Do terpenes explain the effect of the botanical composition of grasslands on cheese?



- ✓ Control milk
- ✓ Control + 0,1 μL oil/L milk
- ✓ Control + 3,0 μL oil/L milk



Mountain sward rich in aromatic plants



Essential oil



Conclusions

- * no effect of terpenes on:
 - cheese microbial counts
 - cheese volatile compounds
- * Direct influence of terpenes on cheese sensory properties with high concentrations



- ↳ *Indirect influence of terpenes not validated*
 - Addition of terpenes in milk \neq plant ingestion?
 - Terpenes = markers of other plant secondary compounds?

Conclusions

Significant effects of cow characteristics and management on cheese sensory properties

Confirm the empirical observations of the farmhouse cheesemakers

Effects < or << effects of cheesemaking process

*Good control of process is necessary
to study the effect of breeds and diets on cheeses*

Interactions identified with different aspects of the process

Some technologies are better suited than others to reveal the effect of breeds and diet

We can only partly explain the effects

*Due to the presence in milk and cheeses of compounds directly transferred from diet or produced by animals or microbes
Role of raw milk microflora? Interactions with substrate?*

Conclusions

Objective references for cheesemakers (PDO, ...)

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

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

Interest to preserve the biodiversity (animal, plant species and microbes) 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



What is a PDO Product?

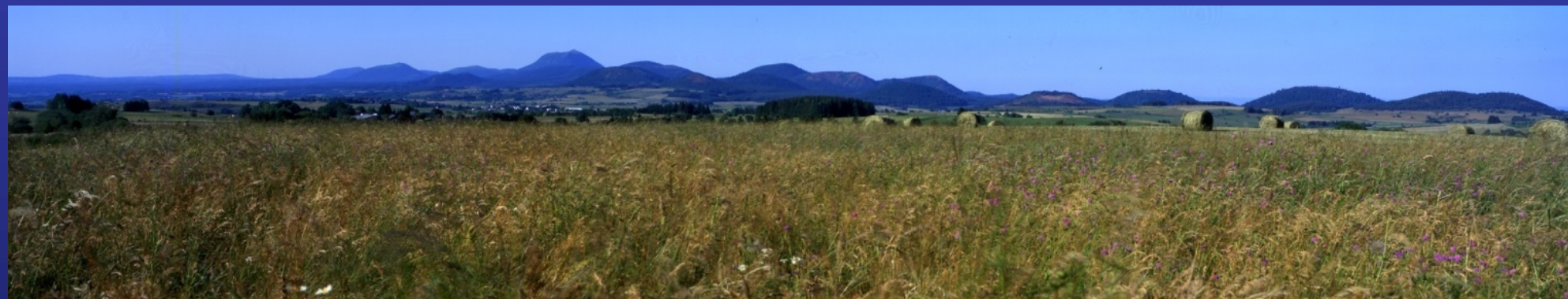
- Definition of PDO :« a product that originate from a territory and whose characteristics are linked mainly to the geographical environment including human and natural factors »»»
EU regulation n°510/2006

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

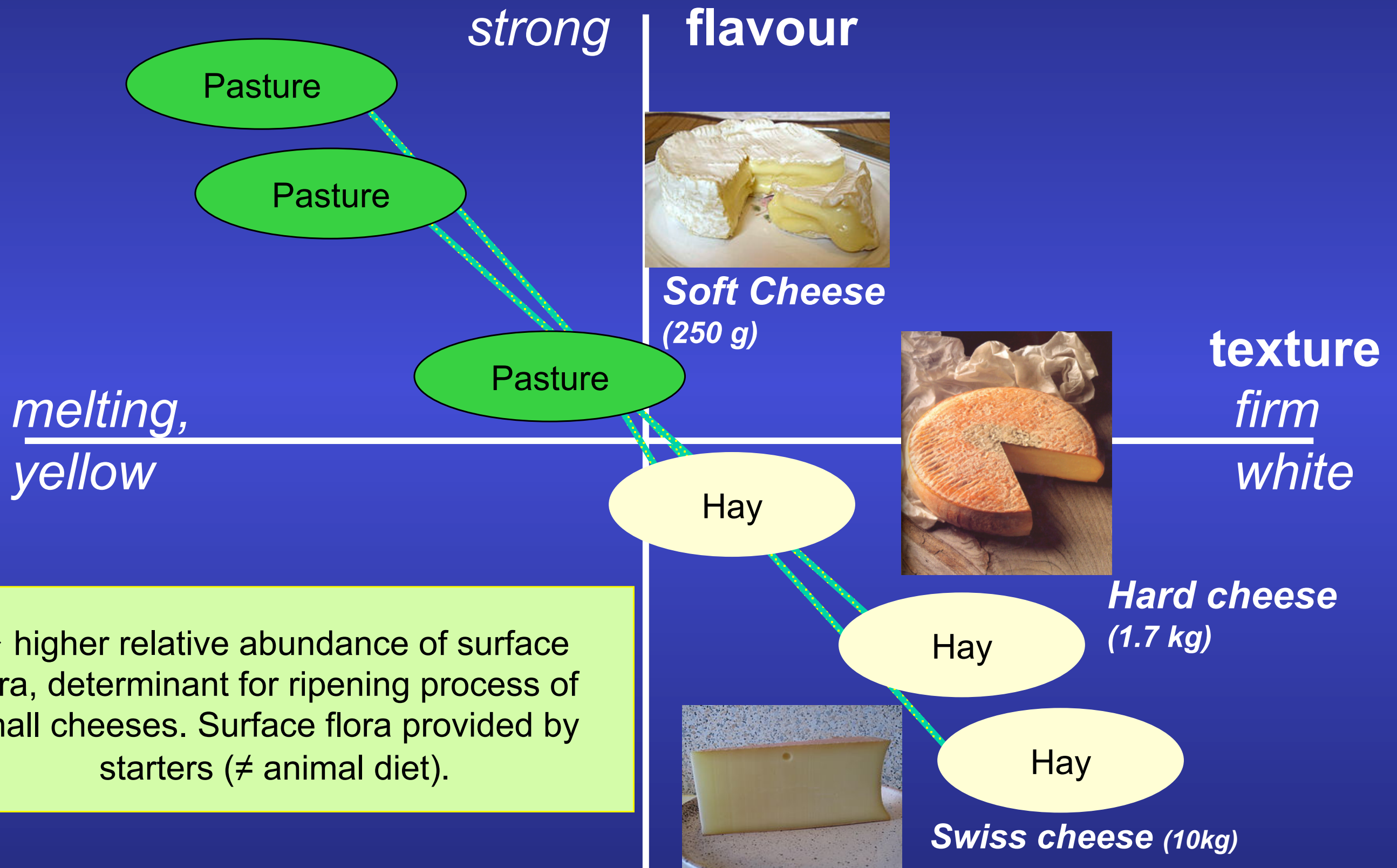
- Definition of terroir : **defined geographical area** where a human community built during its **history** a **collective know-how** for production based on a **system of interactions** between physical, biological and human factors

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

Source : Casabianca et al., 2011



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).

Context

Erosion in consumer confidence in dairy products

Safety, environmental and nutritional issues

Increasing demand about information concerning animal characteristics and management

Positive image of local breeds and grass based diets

Increasing demand for « terroir » products with high sensory quality

Animal characteristics and management are part of the « terroir »

Link between animal characteristics and management and cheese sensory quality?

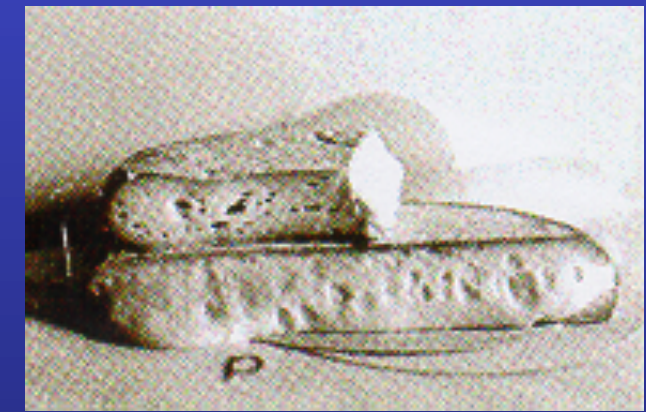
The sensory characteristics of dairy products first depend on cheesemaking process (collective know-how)!

1 raw material = huge diversity of dairy products

The milk characteristics (chemical and microbiological quality) 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

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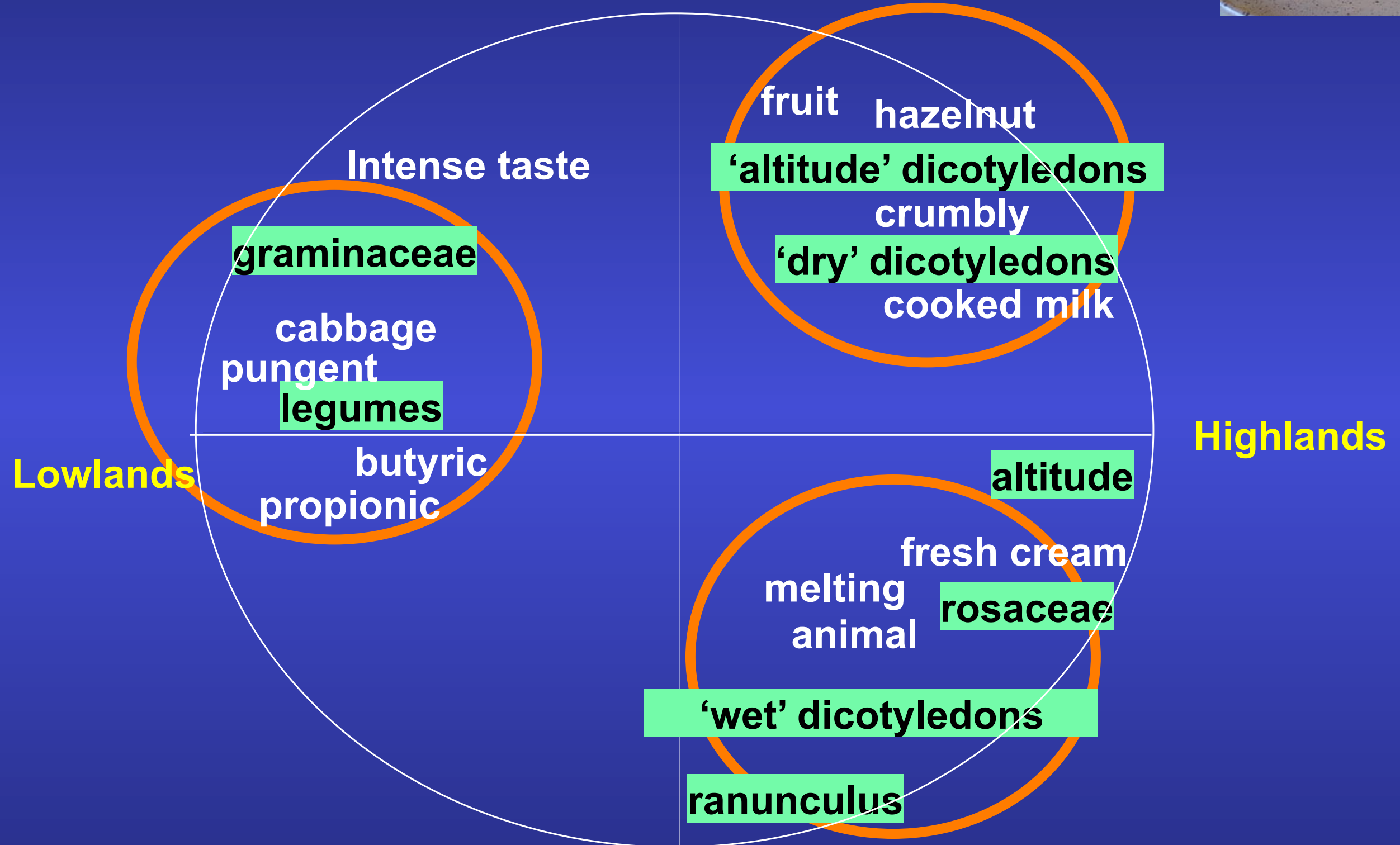
Swiss cheese	Microbial counts				
	Volatile Compounds (other than added)		Marginal modifications		
Hard Cheese	Volatile Compounds (other than added)		Marginal modifications		
	Sensory Properties (0-7) 'Thymus' Aroma	0.1	0.1	/	3.1

Terpenes = markers of other plant secondary compounds?

Buchin et al., 2006

Tornambé et al., 2008

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