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

Bruno Martin, Isabelle Verdier-Metz, Anne Ferlay, Jean-Louis Berdagué, Agnes Cornu, Yves Y. Chilliard, Jean Baptiste J. B. Coulon, Marie-Christine M.-C. Montel

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 Martin[1]

[1]INRA, Joint Research Unit (UMR) Herbivores, Theix, France

Co-workers:

I Verdier-Metz[2], A Ferlay[1], JL Berdagué[3], A Cornu[1], Y Chilliard[1], JB Coulon[1] , MC Montel[2]

[2]INRA, Cheese Research Unit (URF), Aurillac, France

[3]INRA, Animal Product Quality, Theix, France





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

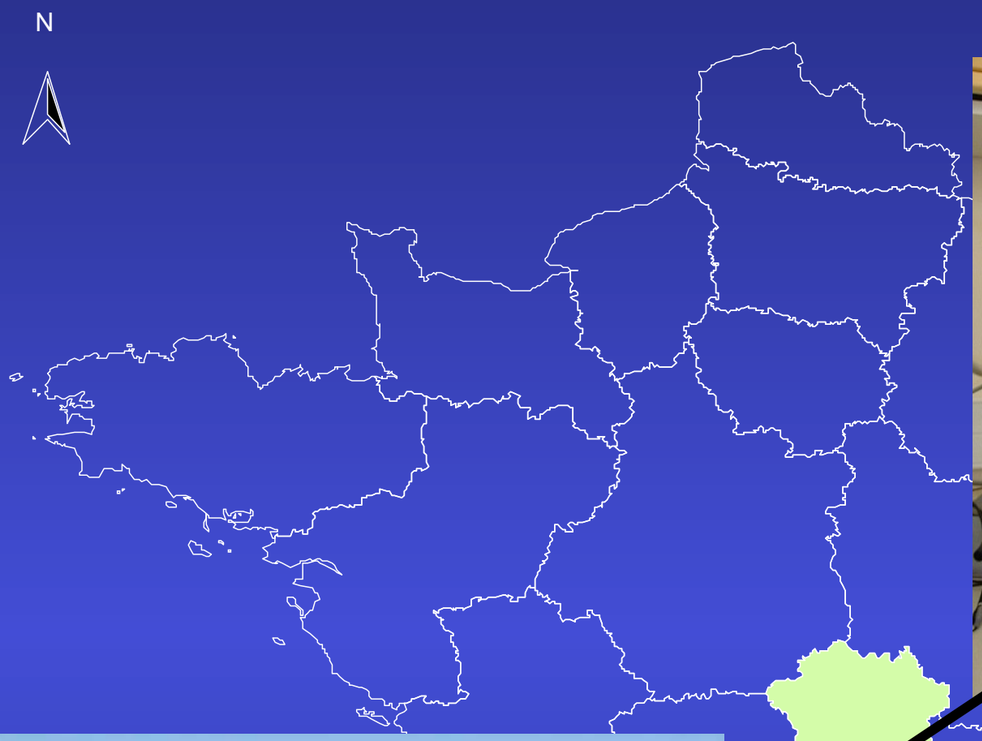
Mountain : 25% of agricultural lands, 20% of the dairy farmers, 14% of the milk, higher production costs (+50 €/1000L)

Animal characteristics and feeding
→ sensory properties of dairy products

So far:

Many empirical observations but few experimental works

The INRA Auvergne facilities



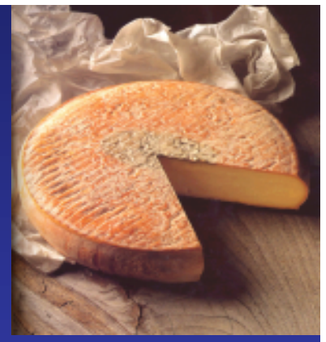
A focus on cattle milk and cheese sensory properties linked to :

Animal genetics

Animal feeding

Milk - Cheese

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



	Holstein		Montbéliarde
		*vs*	
Fat in dry, %	**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 ß-Cas from Tarentaise cows

Variant C of Cas-ß

Specific structure of Cas- ß

Slower breakdown of Cas- ß leading to specific peptides

Large casein micelles, low Ca content

Less firm curd

Fat losses in the whey

FLAVOUR
pungent taste

YIELD
lower 12 to 15%

TEXTURE
less elastic

Delacroix-Buchet et Marie, 1995

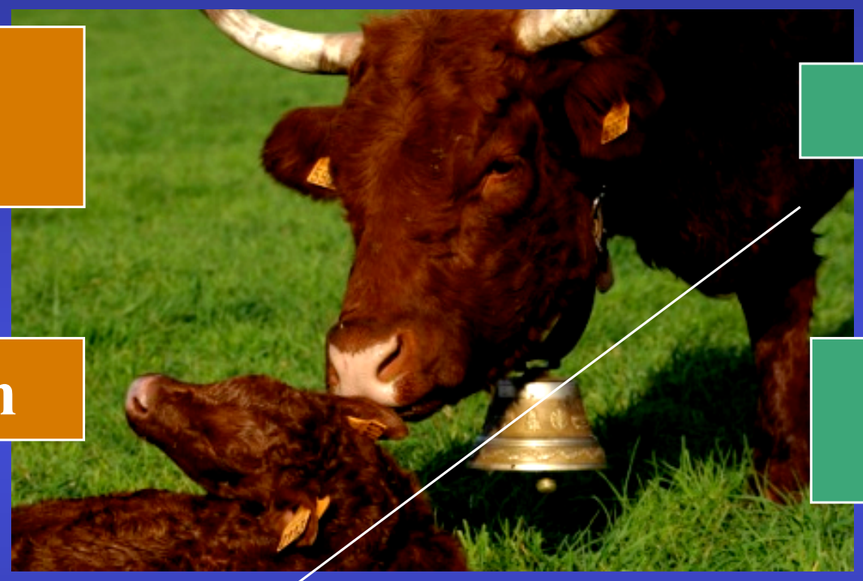
Variant I of κ-Cas from Salers cows

‘Salers’ traditional system

Specific structure of κ-Cas

Slower coagulation

?



Milking with the calf

Low fat content of the milked milk

Specific microbial composition, low somatic cell count

Low Fat in Dry of the cheese

FLAVOUR
slower ripening
softer flavour

TEXTURE
more firm and granular
less melting

Guiadeur et al., 2011; Bianchi et al., 2014

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

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Milk - Cheese

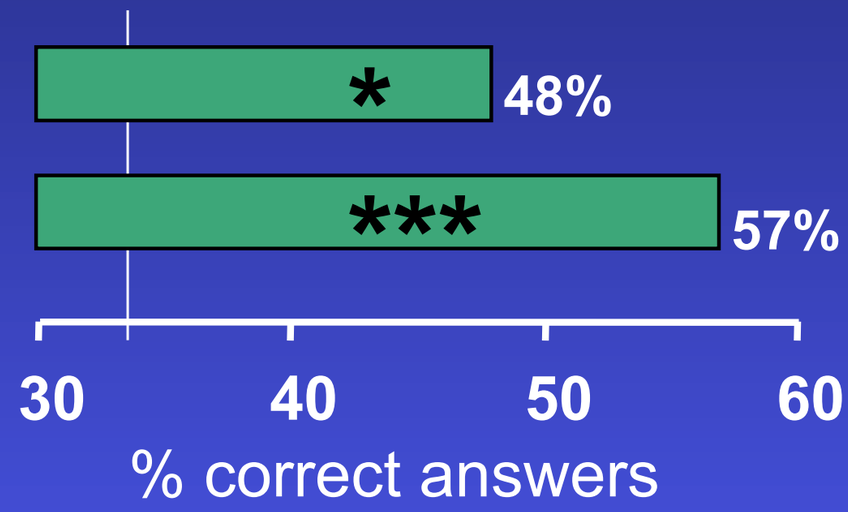
Sensory properties of milk according to the nature of the forage

Raw milk

Pasture *vs* Hay (86%)

Pasture *vs* Concentrate (65%) + Hay

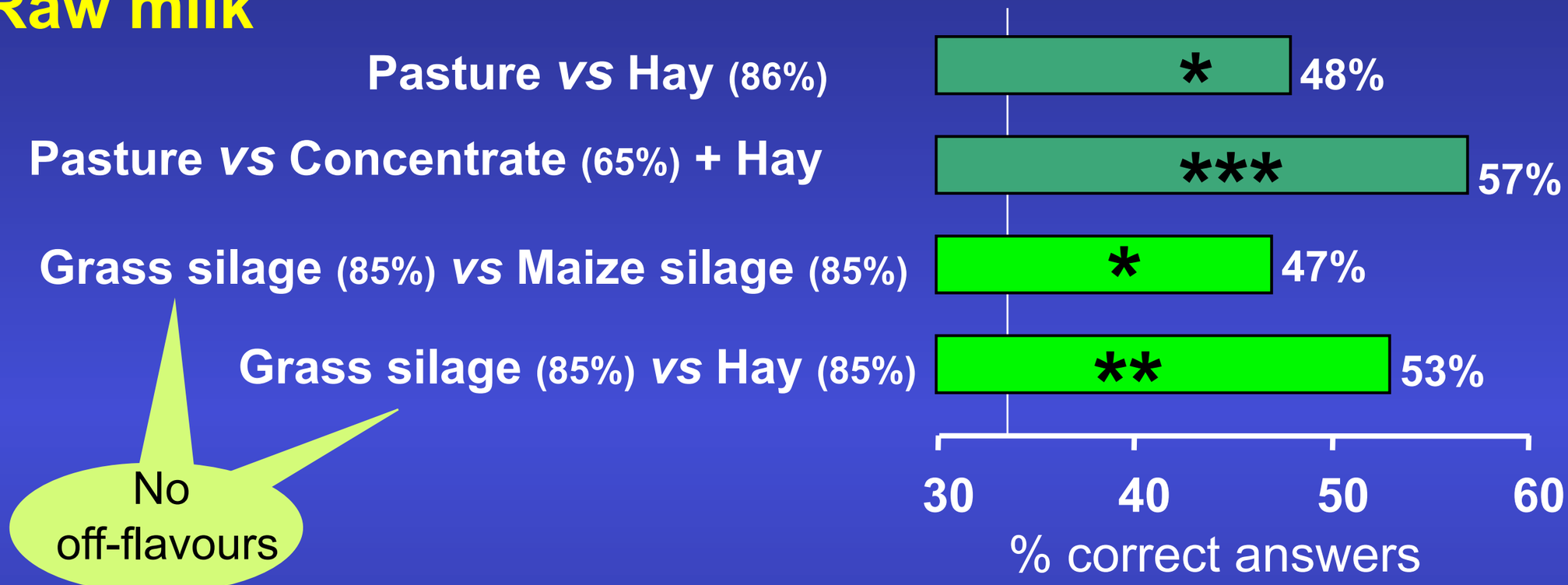
More intense** and barn odour**



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

Sensory properties of milk according to the nature of the forage

Raw milk



No off-flavours

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

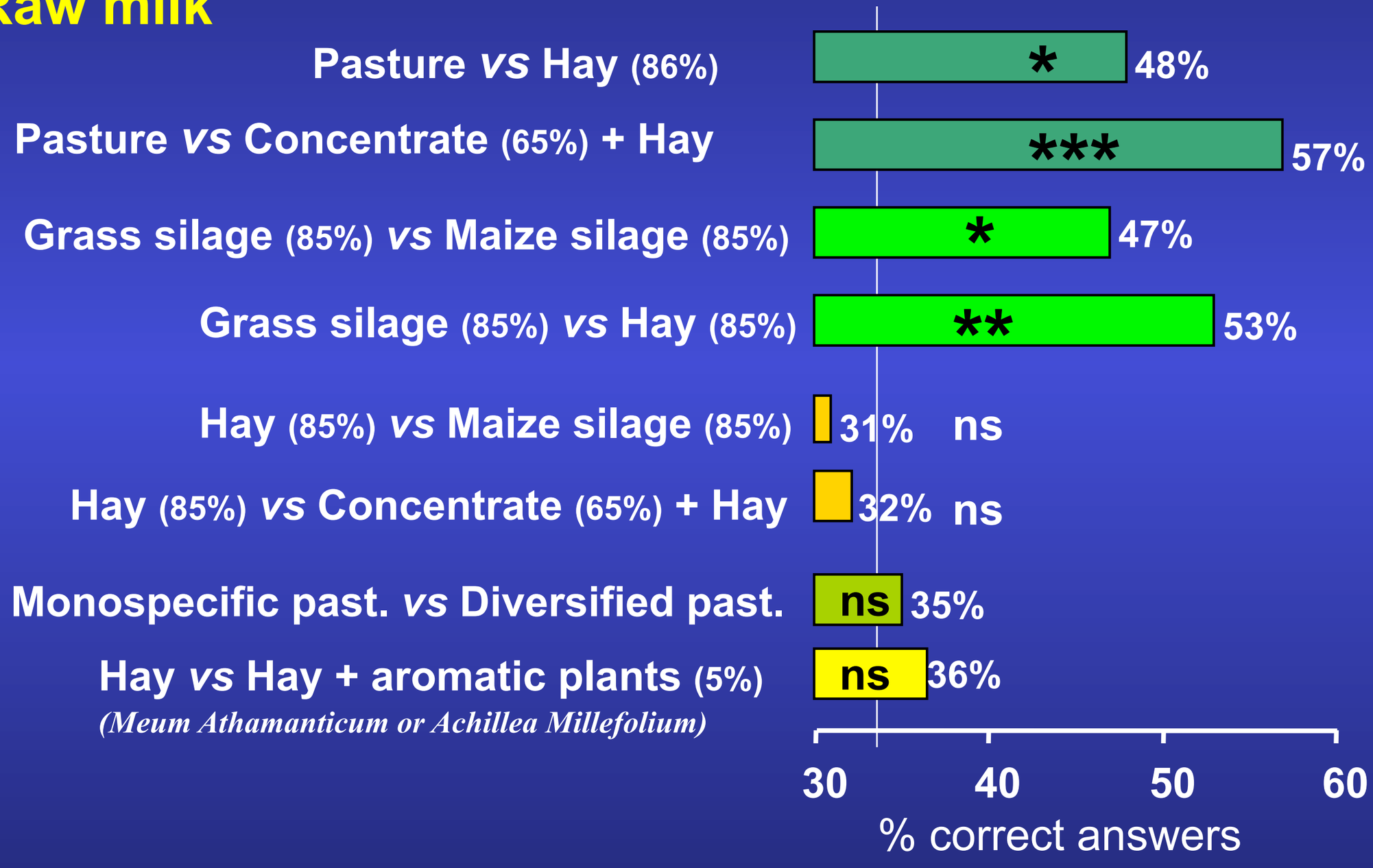
Grass silage and milk off-flavours:

→ 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; Mounchili 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.
Dubroeucq 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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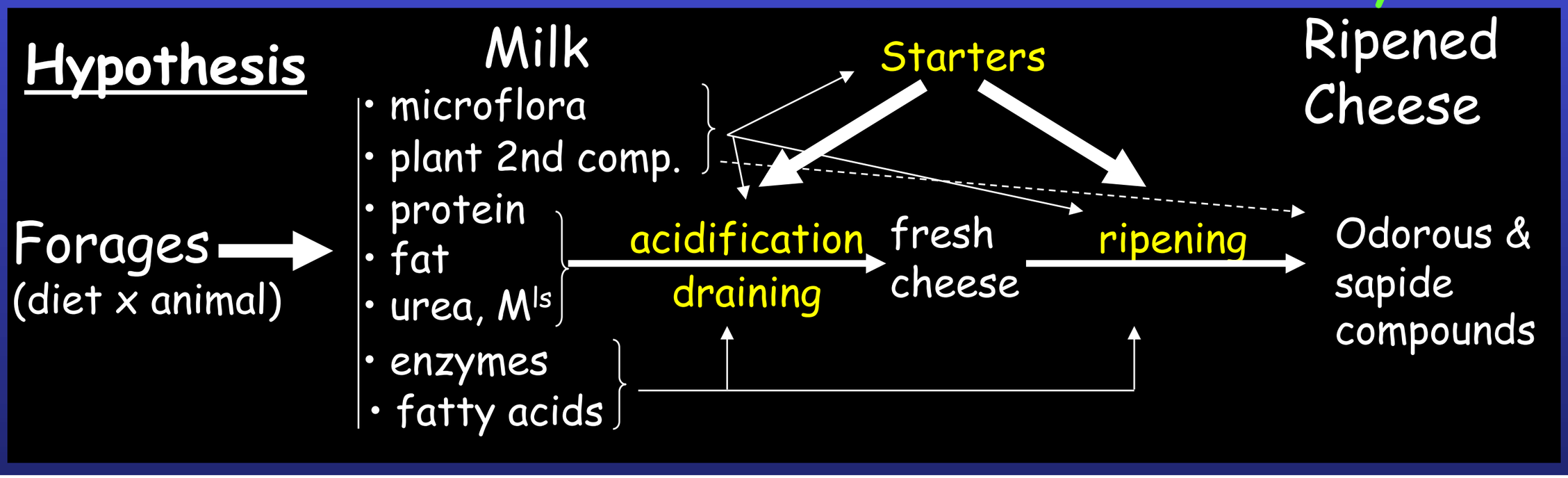
Texture		→ Lower melting point of unsaturated fatty acids	→ Proteolysis	
Firm texture	+	–	–	– –
Flavour		→ ???		
Diversity / intensity	–	+/–	+/–	+/++



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Firm Texture	+	–	–	– –
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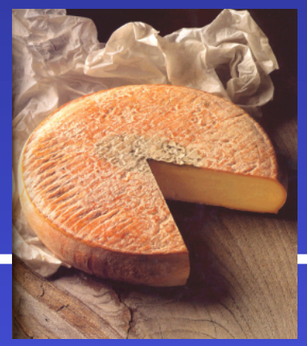
Many interactions with the process…

Forage and cheese sensory properties
interaction with pasteurisation

strong

flavour

Pasture



firm
white

texture

Cantal
Raw milk
Saint-Necta
Raw mil

Concentrate
+ Hay
+ Hay

Cantal
Pasteurised milk

Pasture

Concentrate
+ Hay

melting
yellow

→ 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-Metz et al., 2009

Link to terroir disrupted by pasteurisation?

Verdier-Metz et al., 2000, 2002; Martin et al., 2013

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

Abondance 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

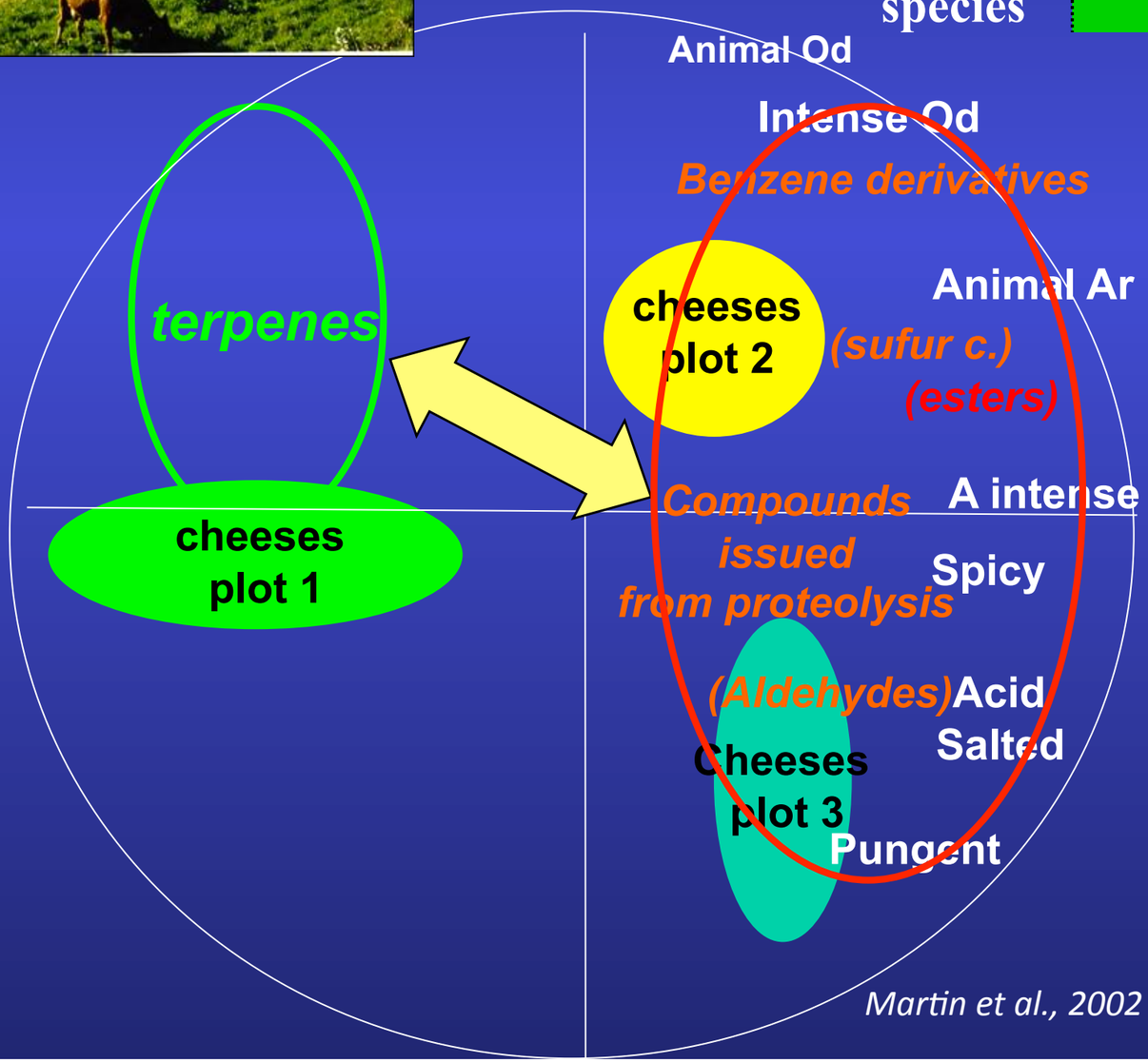
► the effect of the biodiversity of pastures on cheese flavour is weaker and varies during summer

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 % *Festuca rubra*	47 % *Agrostis capilaris*	30 % *Nardus stricta*
Aromatic species	++	=	-



Martin et al., 2002

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

Terpenes :

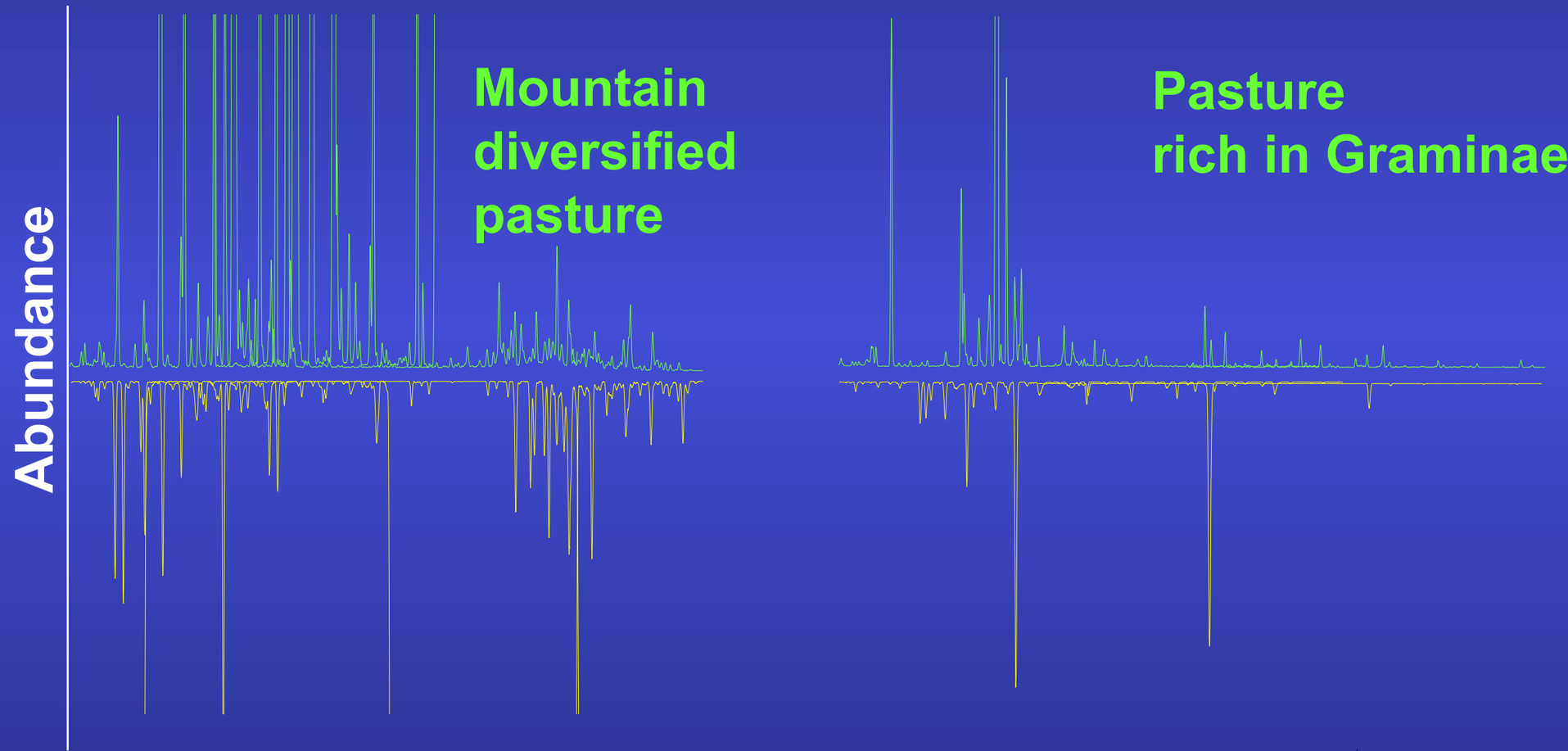
- ✓ Large family of compounds
- ✓ Originate from plants
- ✓ Odorous compounds when concentrated
- ✓ In forages, nature and composition of terpenes = f(botanical composition, phenological stage)
- ✓ Identified in milk and cheese
- ✓ Transferred rapidly from plants to milk

Cornu et al., 2002

Terpenes in grass and in cheeses

(Abondance cheese)

Terpenes composition in grass

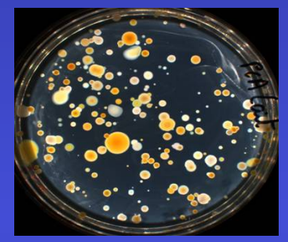


Terpenes composition in cheeses

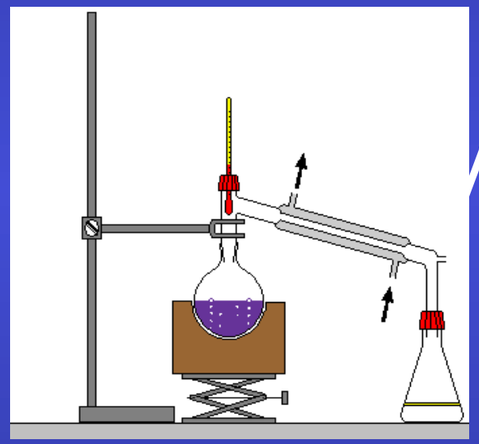
Bugaud et al., 2001

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 ≠ plant ingestion?

→ Terpenes = markers of other plant secondary compounds? *Tornambé et al., 2008*

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

strong | **flavour**

Pasture

Pasture

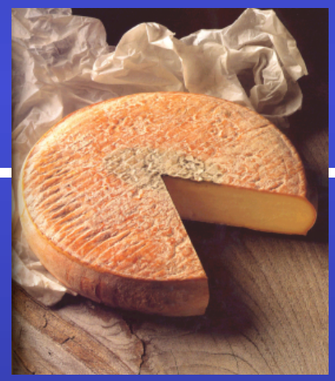
Pasture

Soft Cheese
(250 g)

Hay

Hay

Hay



Hard cheese
(1.7 kg)

Swiss cheese ***(10kg)***

melting, yellow

texture
firm white

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

Verdier et al., 2009

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?

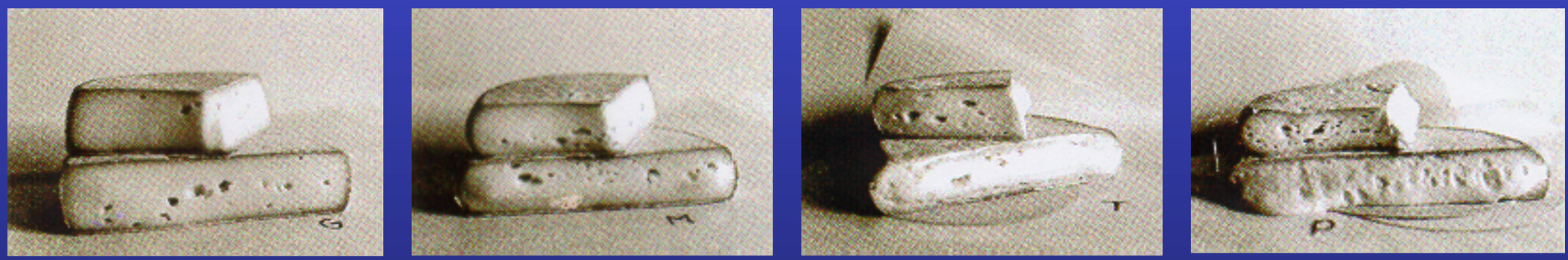
The sensory characteristics of dairy products first depend on cheesemaking process (collective know-how)!

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 mi… sms?

Essential oil added in milk	0	+ 0.1 …	… µg/L	+ 3 µg/L
Swiss cheese — Microbial counts			Marginal modifications	
Swiss cheese — Volatile Com… (other th…				
Hard Cheese — V… Compounds (other than added)			Marginal modifications	
Hard Cheese — Sensory Properties (0-7)				
Hard Cheese — '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 Abondance cheese sensory properties and pasture characteristics

Intense taste

graminaceae

cabbage

pungent

legumes

butyric

propionic

Lowlands

fruit

hazelnut

'altitude' dicotyledons

crumbly

'dry' dicotyledons

cooked milk

Highlands

altitude

fresh cream

melting

rosaceae

animal

'wet' dicotyledons

ranunculus

Axis 1 & 2 of a Principal Component Analysis.
Pasture characteristics: acitve variables
Cheese characteristics: *illustrative variables*

Bugaud et al., 2001