

Blue Cheese Coloration Defects

Browning & pink-brown paste discoloration: causes,
mechanisms,
and prevention

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Compiled from course materials, field photographs, and current research ·

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Actual production example — pink-brown zones in blue-cheese paste

AGENDA

What We'll Cover

1

Presentation of the Defect What it looks like, and when it appears.

2

Generalities: Proteolysis & Glycolysis The chemistry that builds flavour — and defect precursors.

3

Three Main Pathways for the Defect Mechanism, evidence, and prevention for each cause.

4

Other Coloration Defects Not to confuse with this one.

5

Latest Studies What recent science adds to the classic mechanisms.

6

Sources Every reference behind this deck.

What the Defect Looks Like

Light, uneven coloration of the paste — appearing as spots or zones on the cut slice, ranging from pale pink to salmon to reddish-brown.

Typically noticed on random cross-sections around 30 days after production. Healthy paste should stay ivory-white with clean blue-green *Penicillium roqueforti* veining — no discoloration at the edges or around mould holes.

Diagnostic clue: timing matters

Colour appearing within minutes/hours of cutting points to oxidation already “loaded” in the paste. Slower change over days points to ongoing proteolysis or microbial growth in storage.



PART 1 — PRESENTATION OF THE DEFECT

Field Evidence: Real Production Examples

From a faint pink cast at the rind to a pronounced reddish-brown band across the cut face.



Excessive rind activity : investigate yeasts contamination Pathway 3



Linked to presence of oxygen
Pathway 1 or 2

PART 1 — PRESENTATION OF THE DEFECT

From Trial Batches: Labelled Samples

Paired trial cheeses, individually tracked and labelled — the same discipline behind any real investigation.

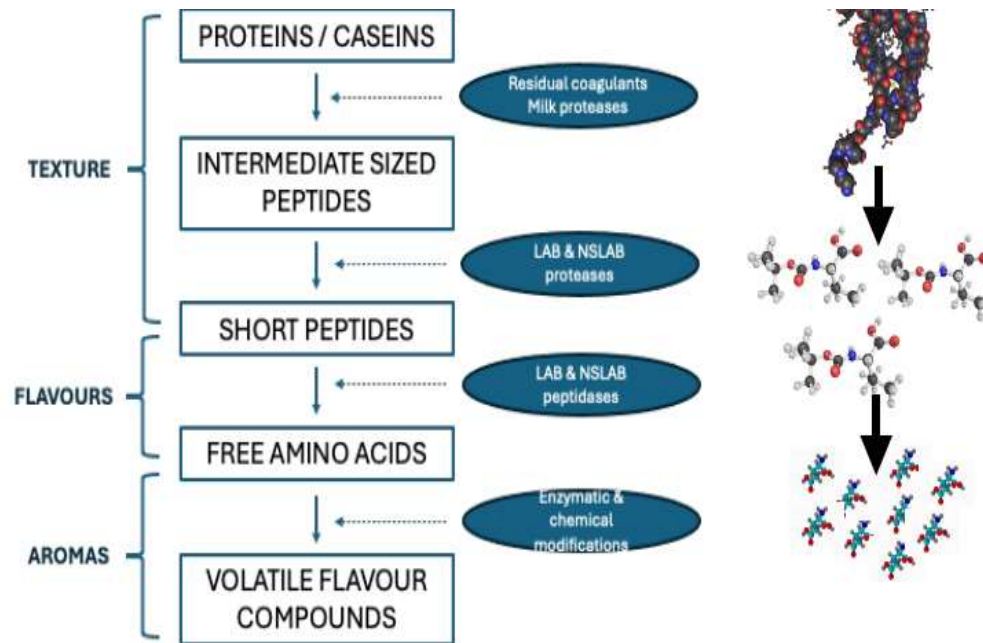


Same batches of cheeses, 30 days apart

Trial samples recovered from Sébastien Roustel course material.

Proteolysis, in General

The breakdown of proteins into flavour — and the same chain that builds the tyrosine pool behind browning.



Why it matters here

Tyrosine — the precursor of Pathway 1's browning pigment — sits inside this exact amino-acid pool.

The more intense the proteolysis (strain, ripening time, temperature), the larger the amino-acid pool available for both flavour development and browning chemistry.

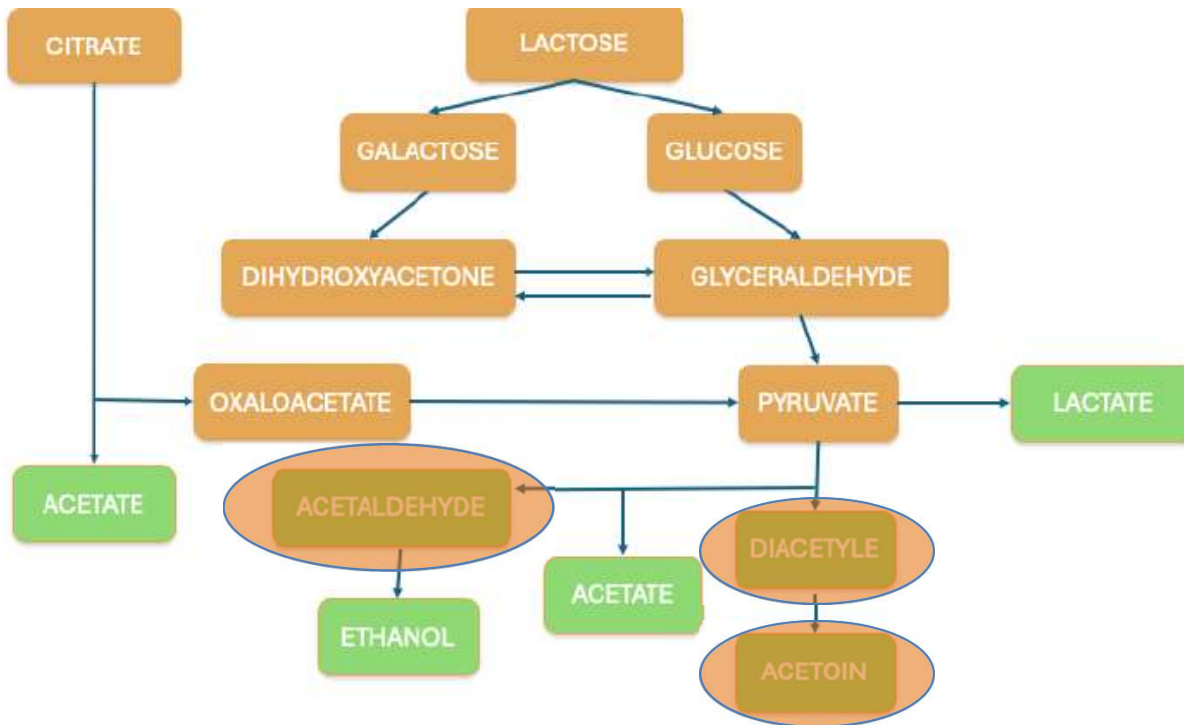
Proteins → large peptides → short peptides → *free amino acids* → volatile flavour compounds.

Short peptides are often bitter; free amino acids are directly tasty; volatile compounds carry the aroma.

PART 2 — GENERALITIES: PROTEOLYSIS & GLYCOLYSIS

Glycolysis, in General

How lactose fermentation builds the two carbonyls behind Pathway 2.



Why it matters here

Lactose splits into glucose and galactose, both funnelling to pyruvate.

Pyruvate is the branch point: reduced to lactate, or diverted by *Lactococcus lactis* diacetylactis toward acetaldehyde, diacetyl, and acetoin — the exact molecules driving Pathway 2's browning.

PART 3 — THREE MAIN PATHWAYS FOR THE DEFECT

Three Pathways, One Symptom

Pink-brown paste discoloration can arise from three independent mechanisms — sometimes acting together.

1

Enzymatic Browning

Penicillium roqueforti proteolysis

Phenylalanine → tyrosine → melanin,
via tyrosinase, catalyzed by
manganese (Mn^{2+}).

2

Maillard-Type Browning

Lactococcus lactis diacetylactis

Yoghurt cultures

Leuconostoc spp

Acetaldehyde from pyruvate metabolism
reacts with free amino acids + oxygen.

3

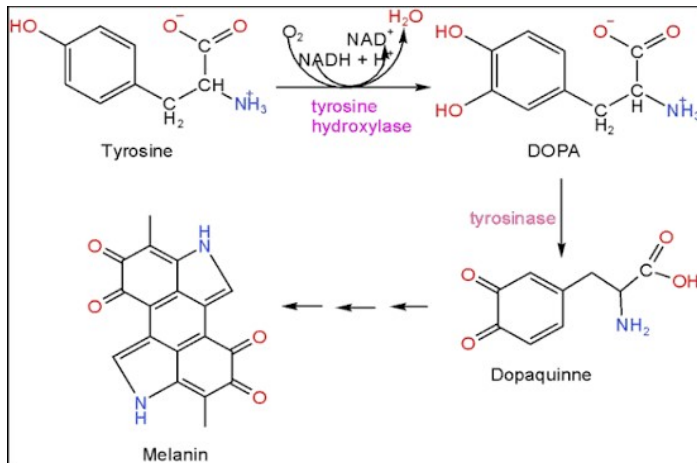
Microbial Oxidation

Candida catenulata / *C. lipolytica*
excess

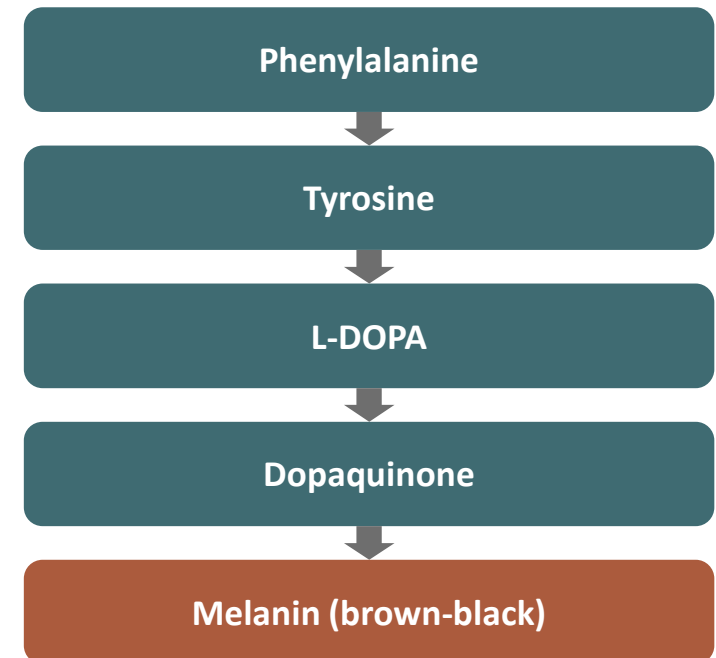
Oxidative yeasts directly oxidize
tyrosine into a melanin-like brown
pigment.

Enzymatic Browning via Proteolysis

- **Penicillium roqueforti** drives intense proteolysis, releasing free amino acids — including phenylalanine, hydrolyzed to tyrosine in the presence of oxygen.
- **Tyrosinase** oxidizes tyrosine to L-DOPA, then dopaquinone; this polymerizes into melanin — a brown-black pigment.
- **Manganese (Mn^{2+})** is the catalyst — a natural soil mineral reaching milk via cow feed, concentrating further through cheesemaking, salt, and brine.

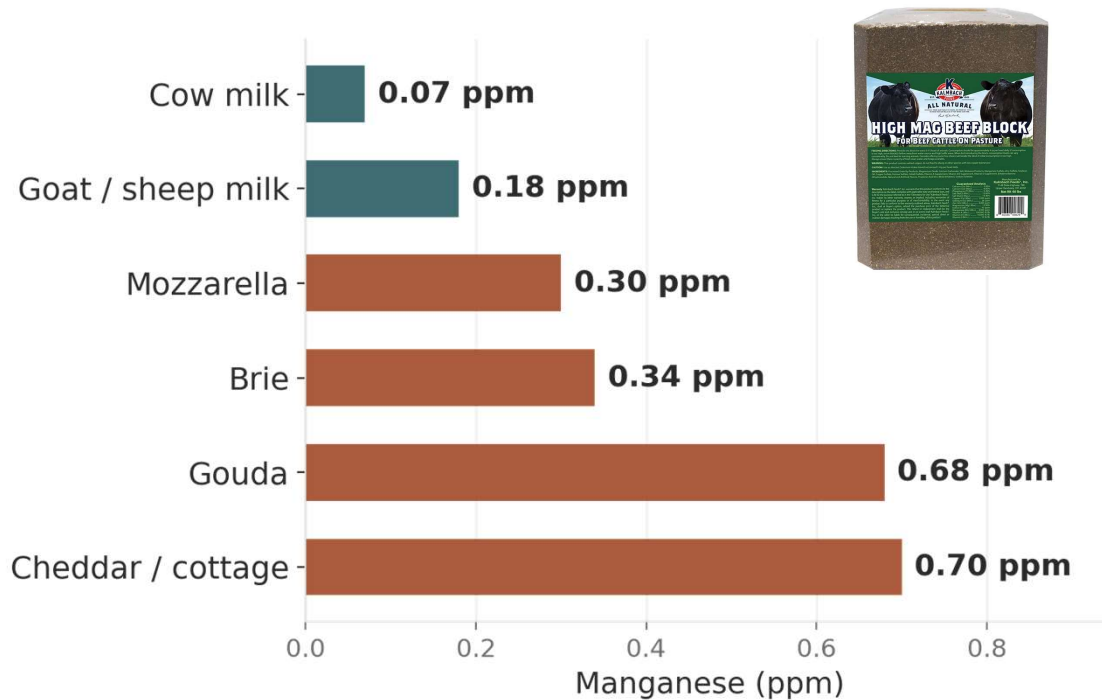


THE PIGMENT PATHWAY



Mechanism per course notes, refined against current tyrosinase/DOPA-melanin literature.

Pathway 1: Manganese & Prevention



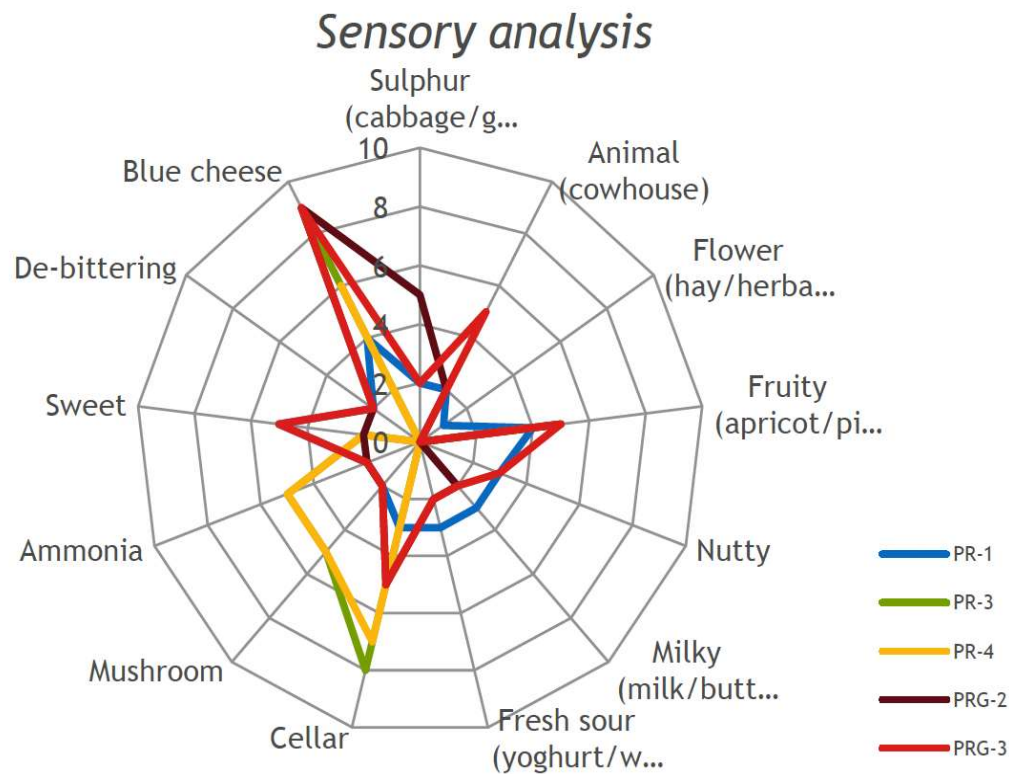
Manganese concentrates roughly 10x from milk into cheese — trace-level control upstream matters.

SOLUTIONS

- Reduce manganese in milk and cheese via mineral supplementation control.
- Check and limit manganese content of salt and brine (<2mg/ L brine – lab’ test only)
- Renew brines regularly — old brines accumulate heavy metals and free amino acids (TA < 30*d)
- Certain protective probiotic strains (such as *Lactocaseibacillus rhamnosus*) help control unwanted pathogens in cheese by competing for and depleting available manganese
- Limit oxygen exposure at cut and packaged surfaces (vacpac or modified atmosphere)

Choosing the Right *P. roqueforti* Strain

Proteolysis intensity is strain-dependent — the same lever that shapes flavour also shapes browning risk.



Source: Novonesis — *P. roqueforti* strain sensory analysis (example chart).

PR-1 *Very low proteolysis*

Mild aroma, no bitterness. Lowest browning risk.

PR-3 / PR-4 *High proteolysis & lipolysis*

Intense blue aroma, creamy texture (Roquefort-style).
Higher browning risk.

PRG-3 *Low proteolysis, high lipolysis*

Fruity, mild (Gorgonzola-style). Lower proteolysis-driven risk.

Diacetyl / Acetaldehyde Browning

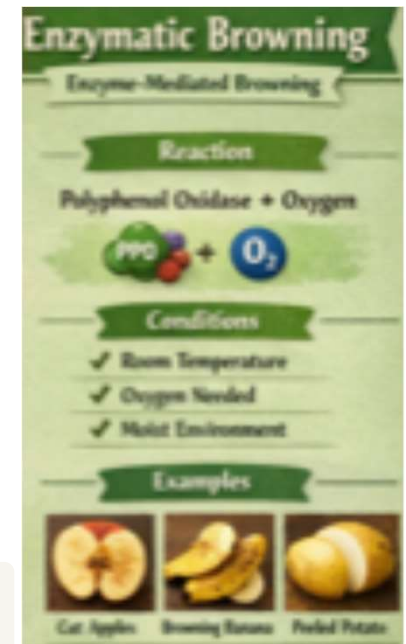
- **Lactococcus lactis diacetylactis** can dominate up to 75% of the lactic starter population. In excess, it overproduces diacetyl and acetaldehyde from pyruvate — the latter often reduced further to ethanol.
- **Acetaldehyde reacting with free amino acids** and oxygen produces a pale brown pigment following an enzymatic browning reaction.

SOLUTIONS

- Reformulate the starter blend to limit diacetylactis dominance, review Leuconostoc Lm dosage.
- Cool bulk starter quickly — slow cooling favours diacetylactis growth.
- Avoid yoghurt-type cultures (*S. thermophilus*, *Lb. bulgaricus* produce acetaldehyde at pH 5–6, 40–52°C).

Sources: course notes; Lucey, "How to avoid color defects in cheese," *Dairy Foods* (2017).

A true Maillard reaction and enzymatic browning are entirely different processes. The Maillard reaction is a non-enzymatic reaction between amino acids and reducing sugars that usually requires heat. Enzymatic browning uses enzymes and oxygen to turn acetaldehydes into brown melanin, creating no complex toasted flavors



Same chemical reaction occurs with others foodstuff like fruits.

Microbial (Yeast) Oxidation : only on cheese's surface, not in the core.

- **Excess growth of oxidative yeasts** — *Candida catenulata*, *C. lipolytica*, *Kluyveromyces marxianus* — can directly oxidize tyrosine into a melanin-like brown pigment (called pyomelanin).
- **Same chemistry, microbial source:** driven by yeast metabolism rather than the paste's own enzymes.



Quantified threshold: as little as 1 CFU/kg of fresh curd can reach 10^5 CFU/g after 21 days at 10°C.

SOLUTIONS

- Change/rebalance ripening yeast flora; select lower-proteolysis ripening agents.
- Hygiene, final rinses with peracetic acid 0,5% of surfaces and equipment.

Meet the Yeasts Behind Pathway 3

The species most often named as the microbial source of the browning defect.

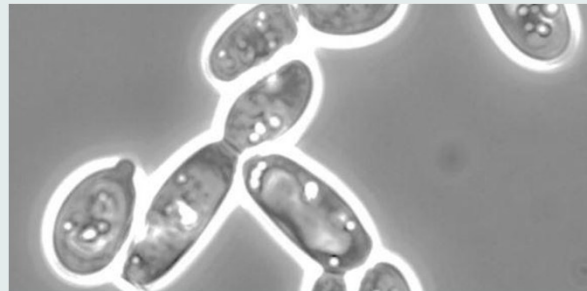


"Catenulata" = Latin for "small chain" — cells bud in visible chains (see photo).

Candida catenulata

now classified as *Diutina catenulata*

Found on white-mould, semi-hard, and blue cheeses. On tryptone-soya/milk agar: gives red-brown colonies — the same pigment family as the paste defect.



Budding, oval cells under phase-contrast microscopy.

Candida lipolytica

anamorph of *Yarrowia lipolytica*

Strong lipolytic AND proteolytic activity — a valued ripening yeast (GRAS/QPS) when in balance. In excess, that activity feeds the tyrosine pool that oxidizes into brown pigment.



Colonies streaked on agar — one of only two yeast species that ferment lactose (the other is *K. lactis*). .

Kluyveromyces marxianus

a thermotolerant dairy yeast

Grows up to ~50°C; converts lactose to ethanol, acetaldehyde, and fruity esters — the same acetaldehyde chemistry behind Pathway 2. Cited among rind/curd contaminant yeasts, often used in commercial yeasts.

Controlling Adjunct Yeast Populations

Seven practical levers, from most to least direct — for when these yeasts are deliberately added as ripening adjuncts.

1

Dosing at inoculation

A defined, calibrated CFU/mL or CFU/g pitch (DVI sachets standardize this). Outcome is directly tied to inoculum concentration.

2

Strain selection

Choose strains characterized for moderate, predictable lipolytic/proteolytic kinetics rather than aggressive wild isolates.

3

Competing flora

Co-culturing with *Geotrichum candidum* and other ripening flora measurably suppresses *Y. lipolytica* growth through competition.

4

Temperature & ripening time

Cooler cave temperatures and a defined (not extended) affinage window slow multiplication.

5

Water activity / salt-in-moisture

Higher S/M and lower aW slow proliferation — a secondary lever, since most cheese yeasts are fairly salt-tolerant.

6

Oxygen control

Limiting O₂ exposure controls the visible browning reaction itself, even if population isn't perfectly controlled.

7

Routine monitoring

Periodic CFU/g counts at defined checkpoints against a set alert threshold — the same logic as the 10⁵ CFU/g figure used for contaminant yeasts.

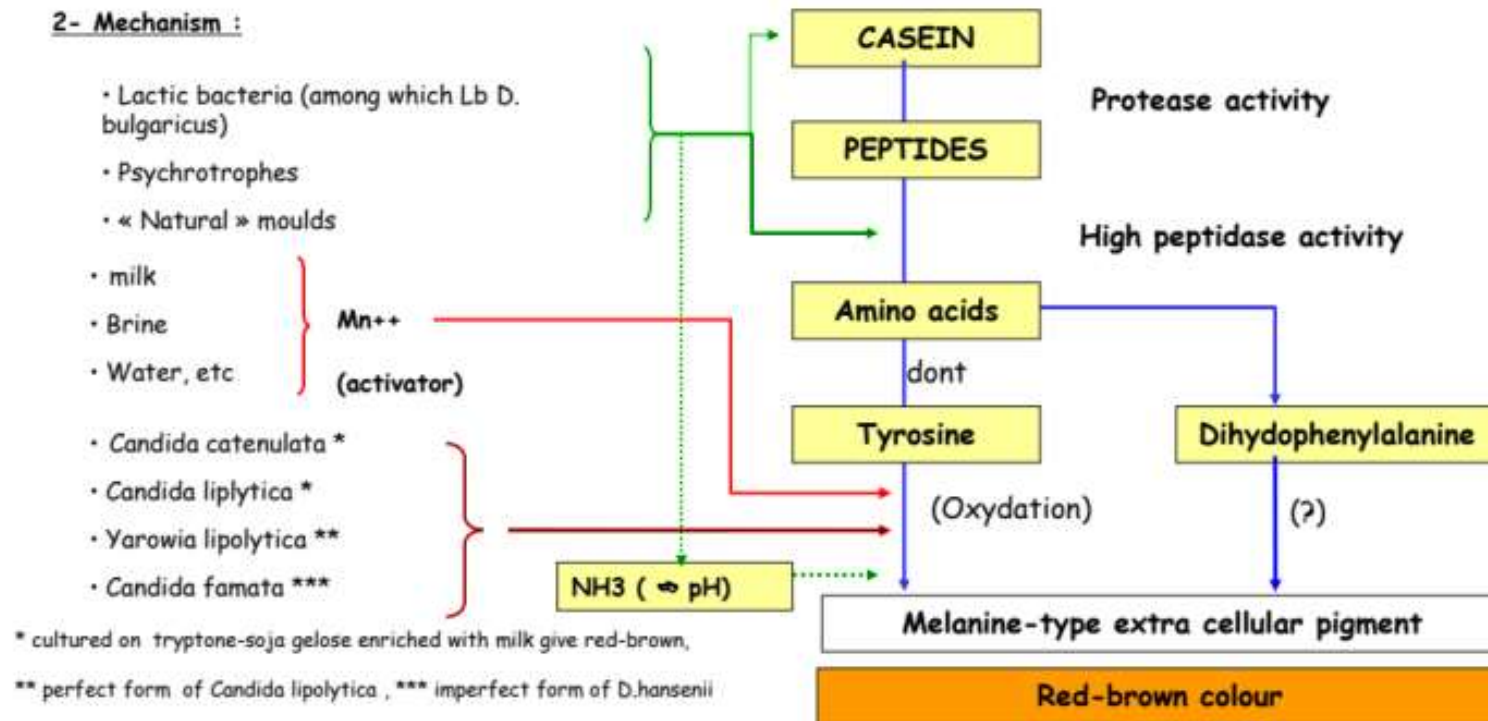
How It All Connects: From Casein to Melanin

All three pathways converge on the same red-brown, melanin-type pigment.

1 - Type of the defect :

- In blue cheese (gorgonzola notably) colour in the curd after cutting
- In semi hard cheese with « natural moulds », Tomme de Savoie type, red/brown line under rind.
- In hard or hard-pressed cheese (grana, manchego) after cutting, reddish colour of curd when aerobic.

2- Mechanism :



PART 3 — SYNTHESIS

Proteolysis breakdown is a normal evolution of the ageing process, without it, no texture evolution nor flavour development. So proteolysis is desired – what is not desired is to lose the control of the proteolytic speed.

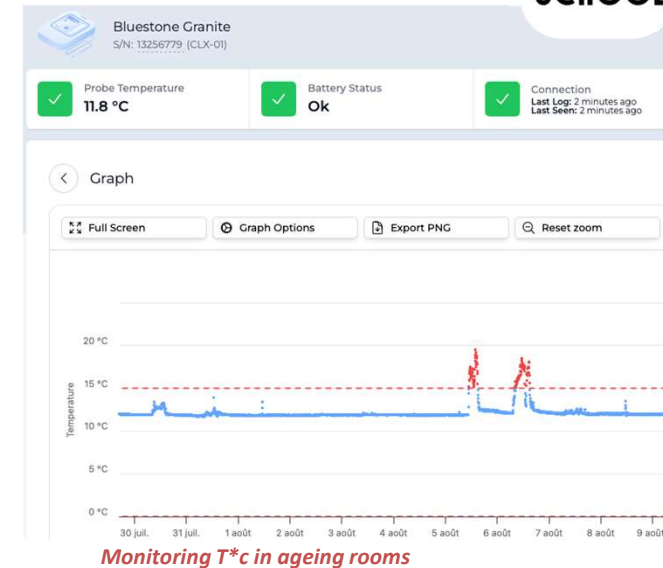
The 3 main factors influencing the speed (catalysts) are:

- **aging Temperature:** the colder the slower, favouring fine proteolysis.
- **Enzymatic load:** milk's flora, type and dosage of commercial cultures.
- **MFFB: Moisture in Fat Free Basis** – the higher the value the faster the ageing process. Identify your MFFB target, tolerance max +/- 1.5 point.

1) ANALYZE BOTH CHEESES WITH AND WITHOUT DEFECTS IN ORDER TO BE ABLE TO COMPARE DEVIANCES : ideally monitor and record as many parameters as possible when everything is OK so we can have data to compare

2) ANALYZE : MOISTURE, PH / TA, SALT LEVEL, CALCIUM, FAT, and eventually : Free Fatty Acids composition , gas production (H₂, Ammonia, CO₂...) , ratio volatile Amino-Acids versus total Nitrogen (assess proteolysis level)

THE CHEESE
SCHOOL



Monitoring cheese composition at unmoulding



Not Every Colour Defect Is This One

The investigation path changes with location, timing, and texture.

PRESENTATION

WHERE / WHEN

LIKELY MECHANISM

Paste / slice pink-brown

After cutting or during storage

Tyrosine oxidation, Mn²⁺, acetaldehyde, yeasts



Surface red / raspberry

Surface, sides, mould holes

Serratia, Rhodotorula, Pseudomonas — aerobic biofilm



Rind yellow/brown ageing

Rind, limited gas exchange

P. camemberti ageing, moisture, packaging O₂/CO₂ transfer



Shelf reddening
“Tablard” red/brown

Board/cave-linked surface

Nitrates/nitrites, ammonia oxidation, cave/boards



Sources: "Coloration Defects" course deck; "Coloration des fromages, origine."

PART 5 — LATEST STUDIES

What Recent Research Adds

New evidence broadens the differential diagnosis — it doesn't replace the classic mechanisms.

2016–2021

Thermus link

Metagenomics and pilot trials associated *Thermus* spp. / *T. thermophilus* with pink defects in some cheeses.

Quigley et al., mSystems (2016); Jonnala et al. (2021)

2022

Pecorino Toscano case

A related pink-discoloration microbial shift was documented in a hard sheep's-milk cheese.

Daghio et al., Food Microbiology (2022)

2024

P. roqueforti pigment genetics

The DHN-melanin pathway controls blue-green spore colour; gene disruptions gave red-pink-brown phenotypes.

Cleere et al., npj Science of Food (2024)

What Recent Research Adds (cont.)

2025

Multi-omics in bloomy cheeses

Pink discoloration correlated with microbiota and metabolite shifts; *Paeniglutamicibacter gangotriensis* reproduced the defect in a model cheese.

Int. J. Food Microbiology (2025)

2026

Blue-cheese pink paste

Shotgun metagenomics associated *Virgibacillus* enrichment with pink paste in an unpasteurized blue cheese.

ASM Microbiology Resource Announcements (2026)

Practical implication: when the classic tyrosine / Mn / starter explanation doesn't fit, compare microbiome or targeted sequencing on affected vs. unaffected paste — not just plate counts.

PART 6 — SOURCES

Sources & References

Course materials

"Blue Cheese Coloration Defects" & "Coloration Defects in Cheese Production" — I. Larcher, The Cheese School.

Original mechanism diagram

Sébastien Roustel — Prevention of Defects, Handouts, Oct. 2014.

Strain sensory data

Novonesis — P. roqueforti strain sensory analysis (example chart).

Flavour chemistry

"Chemistry of Flavours" (Proteolysis, Glycolysis, Generalities), Long Paddock Cheese, internal document, 04/2025.

Fungal pigment genetics

Cleere et al., npj Science of Food (2023/2024).

Pink discoloration, Thermus

Quigley et al., mSystems (2016); Jonnala et al. (2021).

Pecorino Toscano case

Daghio et al., Food Microbiology (2022).

Bloomy-cheese multi-omics & blue-cheese pink paste

Int. J. Food Microbiology (2025); ASM Microbiology Resource Announcements (2026).

Industry practice & reviews

Lucey, Dairy Foods (2017); "A Global Review of Cheese Colour," MDPI (2024).