Success Stories:
Dissolved Air Flotation
We are a trusted partner; serving more than 85,000 customers in over 100 countries with a network of about 9000 employees globally.
The Diversey Corporation was founded on August 4, 1923 by August Kochs and son, Herbert W. Kochs. Diversey Corp. began operations as a separate entity after a public offering. The Molson Companies Limited continued a strategic diversification that included chemical specialties acquisitions. As Molson slowly exited the cleaning chemicals market, it sold most of Diversey in 1996 to the British-Dutch transnational consumer goods company Unilever. As Unilever shifted focus to its portfolio of consumer businesses, the DiverseyLever institutional and industrial cleaning business was sold in 2002 to JohnsonWax. Johnson Wax Professional Founded Public Offering Molson Unilever Johnson Wax Professional Subsidiary license

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Recapitalization Rebrand Sealed Air, Corp. Bain Capital Private Equity DSEY 100 years of Diversey
2009 2010 2011 2017 2021 2023
The Diversey name was sold with all the brands used exclusively by the DiverseyLever operations. JohnsonDiversey, Inc. changed its name to Diversey, Inc. and JohnsonDiversey Holdings, Inc. changed to Diversey Holdings. Sealed Air Corporation announced its intention to purchase Diversey, Inc. In 2013, Sealed Air announced new divisional strategies. Bain Capital Private Equity announced that it was purchasing the Diversey Care division of Sealed Air as well as the food hygiene solution business that was part of its Food Care division to be managed as a stand-alone company. Diversey virtually participated in the iconic bell ringing ceremony at Nasdaq MarketSite marking the date with an initial public offering. Diversey celebrates 100 years of taking care of what’s precious.

OUR HISTORY
Over the course of 100 years, we have continued to refine our suite of solutions, which combines patented chemicals, dosing and dispensing equipment, cleaning machines, services, and digital analysis.
Scaled presence across multiple geographies and solutions allows Diversey to service our customers locally around the world.

**Ease of business**

- Scaled solutions for Global, Regional and Local accounts with multi-channel strategy, programs and technologies for maximum customer benefits
- Commercial excellence with key capabilities, driving resilience, reliability and responsiveness within our business model
- Sustainable and efficiency in operations, aimed at eliminating waste and increasing water savings
- Supply chain with global footprint, delivering the right quality products with reduced time to market

**Manufacturing Plants**
Who are Solenis?
The leading customer-focused global solutions provider for the paper and water treatment industries with revenues of ~ $3 billion

Solenis Vision
“To enable our customers’ success through innovative process and water treatment solutions. We’re proud to work toward a world where true sustainability and operational efficiency is delivered and documented more effectively than anyone could imagine today”

Solenis Mission
“At Solenis, we strive to be each customer’s most trusted supplier by solving problems with the right people, the right experience and the right technology. We’re built to deliver value. Our solutions drive sustainability by reducing water and energy use and raw material waste while improving operational productivity and yields. For the genesis of every solution, our customers look to Solenis”
Our Approach

AquaCheck Water Management Audit → Diagnose Opportunities to create value → Recommend solutions that optimise TCO → Implement solutions correctly to optimise value → Track results to ensure value is delivered

A single point of contact focused exclusively on optimising total water use in the F&B industries and creating value for our customers - delivered by your account manager and Diversey water treatment specialists.

Coupled with the Solenis portfolio of speciality water treatment chemistry and expertise in water monitoring and control systems.
Integrating hygiene and water management

Diversey’s approach to managing hygiene and water quality as a complete system delivers additional value – working to increase efficiency, protect assets, meet regulatory requirements and promoting water reuse, reducing the sustainability footprint of your operations. All through one single point of contact.
Water Treatment Capabilities

Influent Water Treatment
- Coagulation
- Flocculation
- Disinfection
- Softening

Boiler Water Treatment
- Pre-treatments
- Corrosion Prevention
- Scale Prevention
- Condensate System Protection

Cooling Water Treatment
- Pre-treatments
- Corrosion Prevention
- Scale Prevention
- Microbiological Control

Membrane Water Treatment
- De-Chlorination
- Scale Prevention
- Bio-fouling Control
- Membrane Cleaning

Sterilisation and Pasteurisation
- Corrosion Prevention
- Scale Prevention
- Microbiological Control
- Can / Bottle Protection

Wastewater Treatment
- Coagulation
- Flocculation
- Sludge Dewatering
- Foam Prevention
- Odour Control

Process Applications
## Influent and Wastewater Treatment

### Innovative Products

- Coagulants and polymers
- Odor control programs
  - Odor scavengers
  - Odor inhibitors
  - Odor neutralizers
- Antiscalants for Waste Water Effluent Lines – MAP Scaling
- Sludge dewatering polymers
- Antifoams and defoamers

### Program Benefits

- Environmental compliance
- Water re-use
- System sustainability and Reliability
- Safe chemical handling practices
- Improved cake formation and sludge dryness

### Specialized Services

- Applications expertise
- Diagnostic expertise
- Environmental Services
- Critical analysis
  - Microorganism identification
  - Water
  - Foam testing
- Advanced feed and control
  - Automated chemical control system
  - Activated sludge management software
- Vital Few Audits
- Best Practices Audits
Creating Value for the F&B industry

- **Global footprint** to enable the achievement of the rigorous cost & performance indicators
- **Ability to adapt and execute standardized approaches** in a reality of different operational environments
- **Integration of the Hygiene & Water Knowledge** to have:
  - Bio-safe Water Supply across the entire manufacturing process
  - Efficient use of Water in Bottle washing, CIP, Pasteurization and Track Treatment and
  - Reliable and safe supply of water through boiling, cooling and filtration practices
  - Reuse and recycled water integrated (i.e. Cooling water to Track treatment)
  - Energy Efficiency
- **Single point of contact**, entitled to deliver prompt response to all types of inquiries, technical and commercial
- **End-to-end**: holistic approach to income water, effluent water and everything else in between.
- **Reduced procurement complexity**
- **Solenis is one of the few producers** at global level of polymers for WWT applications
• What is Dissolved Air Flotation?
• Why is it used?
• Induced air/forced air flotation
Understanding process: TARGETS AND KPI’s
## Assignment

Waste water treatment technology based on two stage treatment:
1. Physicochemical treatment using the dissolved air flotation process
2. Biological – MBBR sequencing reactor.

Daily flow from 640 to 960 m³ of raw sewage.

## Description

After completing jar test and selecting technology, our customer proposal guaranteed a minimum 20% total cost reduction.

Products selected for:
- Physical and chemical flotation: Amerfloc 481 (30 ppm), Praestol 2640 (8ppm), PIX 113 (580ppm) and PAX11 (300ppm).
- Biological flotation: Praestol 835BS (8ppm).
- Sludge dewatering: Praestol 835BS (150ppm).

Our technology significantly improved stability of WWT process in the area of physicochemical flotation. Additionally, there was a reduction of total phosphorus (from about 20% to 80%) and COD (from about 40% to over 60%).

Total cost reduction - 40%.
Nik-Pol Wastewater Treatment Centrifuge

after dosing Praestol 835BS

dry sludge
Nik-Pol Wastewater Treatment
Physicochemical flotation
Why Optimise?

- Cash Efficiency
- Sustainability
- Carbon Efficiency
- Operational Efficiency
Chemical Dispersion: Pipeline Flocculators or Mixing Vessels?
Correctly Designed Polymer Preparation Systems

- Polymer Storage
- Ageing
- Dissolution
- Dosing
Challenges

- pH correction not fit for purpose, manual dosing of sodium carbonate
- Overdosing coagulant
- Incorrect flocculant choice (due to pH)
- Air dissolving system not coping
- Biological plant consistently not performing
Solutions

- pH correction system replaced by Diversey
- Acid and alkali dosing (reduction in coagulant use)
- Anionic instead of cationic flocculant introduced
- Air dissolving system more consistent
- Biological plant performing well
Next Steps

- Powder polymer dosing systems to be supplied on both DAF and centrifuge
- Remote monitoring
- Partnering with the customer to further optimise other processes on the WWT plant
pH measurement and control

TSS measurement and control
“We’re built to deliver value. Our solutions drive sustainability by reducing chemicals, energy and water used and raw material waste while improving operational productivity and yields”.

Some of the benefits of this project were:

- **Efficacy**, avoiding a wastewater penalty, decreasing the conductivity in the purification process.

- **Operational efficiency**: provide 40% in TCO savings in energy and chemicals mainly.

- **Sustainability**: reducing the carbon footprint
The Role of Cultures & Cagulants in Cheese-making
SDT – Summer Symposium – June 2023
Margaret O’Connell
Chr. Hansen (UK) Ltd.
Overview

- Introduction & History
- Snapshot of the Cheddar Market
- Coagulants
- Starter & Adjunct Cultures
- NSLAB - Non-Starter Lactic Acid Bacteria
Origins & History of Cheese Making

• Cheese making is thought to have originated in the ‘Fertile Crescent’ centered around the Tigris and Euphrates rivers.

• The ‘Agricultural Revolution’ which was the start of domestication of plants and animals (farming and human consumption of animal milks).

• Collection of animal milk + natural environment would have encouraged the acid-coagulation of milk, which on agitation, would have split into curds and whey.

• Egyptian Cheese was being made 6000-7000 years ago.

• Romans – making and trading cheese - La Luna Brand – 300AD.

• Cheddar was recorded as a happy accident in 1100.
Briefly about cheddar cheese

DEFINITION AND TRAITS
Cheddar cheese is the most popular type of cheese in the English-speaking world. Cheddar is described as a natural cheese that is relatively hard, off-white (or orange if colorings such as annatto are added) and sometimes sharp tasting. There are a variety of Cheddar types, each one boasting a different texture and flavor profile suitable for applications ranging from commodity ingredient cheese to a premium table cheese.

CURD/FRESH
Young cheddar-type cheese matures for less than 2 months. It is off-white; however, it has a mild, buttery, creamy, grassy and sweet flavor. Varieties include Colby and Muenster.

MILD/MEDIUM
Semi-mature cheddar ripens for 3 to 6 months. This has a stronger more developed flavor than mild cheddar, with a springier and more coherent texture than cheddar cheese.

MATURE
Mature cheddar typically ripens for 6 to 12 months. Flavor profile is saltier with an intense flavor which lingers on the palate on the finish. This variety has a drier, crumbly texture.

VINTAGE
Vintage cheddars are the strongest of the cheddar varieties and are matured for 12 to 24 months. They are very crumbly, bitey and tangy in flavor. They may also have a spicy or smoky edge.
A quick look at the Global, UK and Irish markets

MARKET FACTS

- Cheddar-types include Monterey Jack, Colby, British Territorials and American cheddar. The types vary from each other in terms of flavor contribution and functionality.
- Global production volume: 4.9 M tons annually.
- 2-3% expected annual growth until 2025.
- US manufacturers produce more than 65% of the global production volume.

VOLUME SHARE OF GLOBAL CHEESE PRODUCTION

- Cheddar: 16%
- Other cheese types

UNITED KINGDOM

Sales of Cheese in United Kingdom
Retail Value RSP - GBP million - Current - 2008-2027

Sales of Cheese in Ireland
Retail Value RSP - EUR million - Current - 2008-2027
Cheese may be considered as concentrated milk

Milk $\rightarrow$ Cheese manufacturing process $\rightarrow$ Cheese

* • Milk quality is key to making high quality cheese – parameters such as salt, moisture and recipe determine the success of the final outcome

* • High quality ingredients are also essential to deliver the required flavour and texture and will drive the direction a cheese will take

* • Maturation is the process of revealing the initial inputs

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• Fat and protein is conc. approx 10 times
• Lactose, whey protein and 95 % of water go to whey
The combination of processing parameters and choice of coagulant, starter and ripening cultures is crucial for the desired characteristics and quality of the cheese product.
Understanding the primary biochemical pathways of cheese ripening

These processes influence the flavor, surface, appearances and ripening speed

- Starter cultures, coagulants, ripening cultures and lipase enzymes affect pathways that influence the ripening of cheese
- The conversion of lactose, citrate, casein and fat contributes to different outcomes for flavor directions, textures, and the formation of eyes
- **Controlling these pathways** will influence the ripening process and ripening speed across all cheese types
The proteolytic pathway: a summary

1. PRIMARY PROTEOLYSIS: STRUCTURE AND CONSISTENCY (LOW ACTIVITY)
   - Indigenous milk proteases - plasmin
   - Proteases from psychrotrophic bacteria
   - Coagulant
     - Dosage + C/P-ratio = proteolytic impact
   - Starter culture protease

2. SECONDARY PROTEOLYSIS: TASTE (HIGH ACTIVITY)
   - Starter, adjunct, NSLAB
     - High Peptidase
   - Inoculation rate
   - High lysis

3. TERTIARY PROTEOLYSIS: AROMA (BALANCED)
   - High amino aminotransferase
Coagulants
Specificity (C/P-ratio) of coagulants matters as it disclose the performance

**THE C/P RATIO**

- **C** Clotting activity
- **P** General proteolytic activity

**CASEIN SUBSTRATE**

- **K** Kappa Casein
- **α, β** α, β peptides

**EFFECT**

- The higher clotting activity the more precise cutting of Kappa Casein and ability to form strong casein network
- The proteolytic activity impacts the speed of breakdown of casein in bigger and smaller peptides (fast speed gives bitter taste)

**IMPACT**

- Use of a coagulant with a high C/P ratio results in a stronger casein network and fat and proteins are kept in the cheese
- Cheese yield is directly linked to the C/P ratio of the coagulants

---

1 C/P is the ratio between the specific clotting activity and general proteolytic activity. Reference method by E045
1 Analysis method = 50 IMCU/L Milk, pH 6.5. 3 Analysis method = Curd simulation & peptides extraction
A more specific coagulant enables precise cutting of the kappa casein and allow strong network formation

**SPECIFICITY**

What is specificity?
- Specificity is the degree of precision which the Kappa caseins are cut during coagulation
- The specificity varies dependent on the type and generation of coagulant

**INSTABILITY**

Coagulant is added, CMP released after cleaving Kappa casein

**COAGULATION**

Casein network formed as destabilized micelles aggregate into curd
Higher specificity (C/P ratio) leads to faster coagulation and higher yield

**BETTER NETWORKS, HIGHER YIELD**

Influence of specificity

- The more precise the micelles are cut, the better networks they form and the more you keep what you need in the cheese without affecting the quality of the whey

- Using a coagulant with high C/P-ratio gives a superior network capturing fat and retaining intact proteins

**LOW C/P RATIO**

- Broken proteins
- Lost fat

**HIGH C/P RATIO**

- Casein network is strong and captures optimal levels of fat with minimal protein breakdown
Our range includes different ratios of specificity and fulfill the desired outcome of individual cheese productions.

**SPECIFICITY (C/P)**

**NATUREN®**
Keeping traditions alive

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**MICROLANT®**
Making organic possible

<table>
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<tr>
<td>Supreme</td>
<td>80</td>
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**CHY-MAX®**
For the modern cheese era

**Parameters to consider when selecting:**

- More yield vs. cost vs. maturation
- Strong flavor impact and bitterness
- Desired functionality:
  - sliceability,
  - melt-ability,
  - shelf-life
- Whey quality
- Coagulant choice depends on cheese requirements

1 C/P is the ratio between specific clotting activity (IMCU/ml) and proteolytic activity.
Coagulant selection will deliver the desired level of intact caseins\(^1\) throughout shelf-life

**PROTEOLYTIC ACTIVITY ACROSS COAGULANTS\(^2\)**

<table>
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<tr>
<th>Coagulant Type</th>
<th>Soluble Protein % of Total</th>
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<tr>
<td>Microbial XP type</td>
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<td>CHY-MAX® Supreme</td>
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<td>FPC 1st gen microbial XP</td>
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<tr>
<td>FPC 2nd gen microbial XP</td>
<td>4.7</td>
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<tr>
<td>CHY-MAX® Supreme</td>
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</table>

- **8 days**
- **30 days**
- **60 days**

- CHY-MAX® Supreme is **53% less proteolytic** after 60 days compared to 1st gen microbial meaning **53% more soluble proteins** are recovered in the cheese after 60 days.
- When stored at 5\(^\circ\) C/ 41\(^\circ\) F the shelf life can be extended from **2 to 4 months**.
- The high level of intact caseins provides a superior **functionality** incl. **texture** of the cheese which enables easy conversion of the cheese with less giveaways.
- In addition shelf life and the **window** for conversion is **extended**.

---

1. Compared to other coagulants in the market
2. Trials in Chr. Hansen’s facility.
Trends in the market

YIELD AND FUNCTIONALITY
• Continuous focus on maximizing value of milk through higher cheese yield and better whey quality
• Increasing demand for cheese as an ingredient and convenient formats call for functionality improvements during production

PRESERVATIVE-FREE AND ORGANIC
• Big surge towards preservative-free coagulants globally
• Increasing consumer interest for organic and more natural foods with fewer ingredients

SUSTAINABILITY
• UN global goals as a proactive tool to measure business impact. For instance ensuring sustainable consumption and production patterns

1 Euromonitor 2017 - 2020  2 Mintel GNPD 2017 - 2020
A market leading coagulant portfolio

Chr. Hansen offer the most extensive range of superior coagulants which can fulfill every need of a cheesemaker whether it requires traditional cheesemaking, organic production or is for the modern industrial cheese production.

VOLUME SHARE OF GLOBAL COAGULANT USE

1 Fermentation Produced Chymosin
2 Coagulant specificity is the ratio between desired and undesired protein breakdown. High specificity leads to firmer texture and reduced bitterness and vice versa.
3 Yield varies depending on the cheese process incl. the temperature of pasteurization.
Culture
Starter Cultures - Functionality

**PRIMARY**

The primary function of a starter culture is to produce lactic acid from lactose in milk.

Starters convert lactose into glucose and galactose - then ferment the glucose component to lactic acid and reduce the pH of the milk/curd.

**SECONDARY**

The secondary function of a starter culture is to create the flavour and aroma that underpins cheese flavour & aroma producing.

**AROMA**

• Compounds that interact with olfactory receptors
• Organic compounds
• Compounds with a certain level of volatility

**TASTE**

• Compounds that interact with olfactory receptors
• Organic compounds
• Compounds with a certain level of volatility
The proteolytic pathway: a summary

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   - High lysis

3. TERTIARY PROTEOLYSIS: AROMA (BALANCED)
   - High amino aminotransferase
## Analysis of Cheddar cheese from AU, NZ and UK markets: Composition

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<td>35.9</td>
<td>2.3</td>
<td>6.3</td>
<td>5.42</td>
</tr>
</tbody>
</table>
Analyzing commercial Cheddar cheese from AU, NZ and UK markets: *Free amino acids and organic volatile compounds*

- Large concentration range of total free amino acids spanned with some (small) differences in composition. Absence of GABA.
- Large differences in the relative intensities of volatile compounds with separation of samples into 5 main flavor profiles.
The autolysis of starter and ripening cultures greatly enhances cheese ripening, by releasing nutrients and enzymes into the cheese serum.

Environmental stress exposure during cheesemaking and ripening (temperature, salt, pH, nutrient starvation) induces cell permeabilization or complete cell autolysis.

Fig 1: Average starter and non-starter lactic acid bacteria (NSLAB) densities (CFU/g) in Cheddar cheese manufactured with similar composition (pH, S/M, MNFS) from 3 New Zealand factories (Crow et al. 1995).

Fig 2: Schematic representation of nitrogen metabolism in lactic acid bacteria. Abbreviations refer to the enzymes of Lc. lactis (Parente & Cogan, 2004).
Cheddar cheese made with *Lc. lactis* single strains previously screened to different levels of Pro-specific aminopeptidase activity

Correlation between temperature-induced lysis screening and Cheddar cheese. Strains with lysis index > 0.25 (Medium and High) demonstrate good flavour properties. Linear correlation between CFU, PepX and total FAA until 6 months of age. After 6 months the starter culture is no longer the dominant bacterial population in the cheese, and PepX no longer a sufficient single marker of the ripening stage.

Use of additional enzymatic flavor markers would further complement the analysis of biochemical compounds and elucidate the microbial species and metabolic pathways.
Citrate utilization by lactic acid bacteria without associated gas formation: The

Fig 1: General overview of the biochemical pathways contributing to flavour and texture development during cheese ripening (McSweeney, 2004)

Fig 2: Conversion of citrate to succinate via the reductive TCA pathway by *Lactiplantibacillus* as first suggested Chen & McFeeters, 1986
Analyzing Premium US Cheddar made with 5 different EASY-SET® cultures: Lipolysis

- Lipases and esterases of lactic acid bacteria as principal lipolytic agents (intracellular enzymes)
- Similar FFA profiles with low levels of total FFA and increasing by 10-15% between 60 to 180 days of storage
**CR-200 & CR-300 – debittering strength**

*Lactococcus lactis & cremoris* efficiently reduce bitterness by limiting primary proteolysis and boosting peptide breakdown.

**PROTEINASE ACTIVITY**
Relative %

- **Primary proteolysis** - the ability to break down intact proteins and larger peptides.

<table>
<thead>
<tr>
<th>Culture</th>
<th>Relative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR-213</td>
<td>100</td>
</tr>
<tr>
<td>CR-312</td>
<td>70</td>
</tr>
<tr>
<td>CR-319</td>
<td>60</td>
</tr>
</tbody>
</table>

**PEPTIDASE ACTIVITY**
Relative %

- **Secondary proteolysis** – the ability to break down peptides to free amino acids.

<table>
<thead>
<tr>
<th>Culture</th>
<th>Relative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR-213</td>
<td>100</td>
</tr>
<tr>
<td>CR-312</td>
<td>30</td>
</tr>
<tr>
<td>CR-319</td>
<td>90</td>
</tr>
</tbody>
</table>

**AUTOLYSIS**
Autolysis index (PepX activity)

- **Autolysis** – the ability of the cells to lysis helps to speed the ripening process.

<table>
<thead>
<tr>
<th>Culture</th>
<th>Autolysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR-213</td>
<td>0</td>
</tr>
<tr>
<td>CR-312</td>
<td>1</td>
</tr>
<tr>
<td>CR-319</td>
<td>8</td>
</tr>
</tbody>
</table>

Data can be compared between the cultures presented in the graphs above but cannot be compared to data from other culture ranges.
*Lactobacillus helveticus* – Solutions for Flavour Development

*Lactobacillus helveticus* has a highly efficient proteolytic system that breaks down milk proteins to peptides and free amino acids. The good balance between proteinase and aminopeptidase activities is responsible for the good action on bitterness control.

**Primary proteolysis** - the ability to break down intact proteins and larger peptides.

**Secondary proteolysis** – the ability to break down peptides to free amino acids

**Tertiary proteolysis** – the ability to transform free amino acids into volatile compounds

Data can be compared between the cultures presented in the graphs above but cannot be compared to data from other culture ranges.

Emfour®: Restricted in use: Contact Marketing.
Delight01: Heat attenuated.
We offer a wide range of starter & adjunct cultures for Cheddar

All cultures are optimized for coagulant and adjunct use.
Culture - NSLAB
The proteolytic pathway: a summary

1. PRIMARY PROTEOLYSIS: STRUCTURE AND CONSISTENCY (LOW ACTIVITY)
   - Indigenous milk proteases - plasmin
   - Proteases from psychrotrophic bacteria
   - Coagulant
     - Dosage + C/P-ratio = proteolytic impact
   - Starter culture protease

2. SECONDARY PROTEOLYSIS: TASTE (HIGH ACTIVITY)
   - Starter, adjunct, NSLAB
     - High Peptidase
   - Inoculation rate
   - High lysis

3. TERTIARY PROTEOLYSIS: AROMA (BALANCED)
   - High amino aminotransferase
Variation in NSLAB Levels in Mature Cheddar Samples

- NSLAB (Non-Starter Lactic Acid Bacteria) are principally facultatively heterofermentative lactobacilli

- E.G. Lb. brevis, Lb. curvatus, Lb. casei, Lb. plantarum, Lb. fermentum

- Present as opportunistic organisms in the milk and dairy (biofilms)

- They tend to present at very low numbers initially, but will build up during maturation

REF: microorganisms-10-01669-v2.pdf
Heterofermentative lactobacilli have additional capacity to produce other metabolic end-products, e.g. acetate.

This pathway also produces lactic acid, ethanol and CO₂.

Carbon dioxide produced by this pathway can contribute to open texture development in Cheddar.

Fruity flavour notes can arise from heterofermentative pathway especially through the breakdown of ethanol to esters, which are associated with fruity notes.

<table>
<thead>
<tr>
<th>Homofermentative</th>
<th>Heterofermentative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>Glucose 6-P</td>
</tr>
<tr>
<td>Glucose 6-P</td>
<td>Glucose 6-P</td>
</tr>
<tr>
<td>Fructose 6-P</td>
<td>6-Phosphogluconate</td>
</tr>
<tr>
<td>Fructose1, 6-di-P</td>
<td>2-Keto-6-phosphogluconate</td>
</tr>
<tr>
<td>Glyceraldehydes 3-P</td>
<td>Ribulose 5-P</td>
</tr>
<tr>
<td>1,3-diphosphoglycerate</td>
<td>Xylulose 5-P + CO₂</td>
</tr>
<tr>
<td>3-phosphoglycerate</td>
<td>Glyceraldehydes 3-P</td>
</tr>
<tr>
<td>2-phosphoglycerate</td>
<td>Acetyl-P</td>
</tr>
<tr>
<td>Phosphoenol pyruvate</td>
<td>Pyruvate</td>
</tr>
<tr>
<td>Pyruvate</td>
<td>Acetyl Co-A</td>
</tr>
<tr>
<td>Lactic acid</td>
<td>Acetaldehyde</td>
</tr>
<tr>
<td></td>
<td>Ethanol</td>
</tr>
</tbody>
</table>
Crystal Formation in Cheddar

• **Calcium Lactate**
  - D- and L-Lactate – 2 isomers present in cheese
  - The majority of L-lactate in Cheddar is produced by the starter cultures primarily on the day of manufacture (typically 1.2-1.5% lactic acid)

  • **D-Lactate has a lower solubility and is produced by the NSLAB population either by**

  \[
  \text{Ca}^{2+} + 2 \text{Lactate}^{-} \quad \text{Ca Lactate}_2^2 \quad \text{Ca Lactate}_2^2 \\
  \text{(Soluble)} \quad \text{(Nucleated crystals)} \quad \text{(Visible crystal formation)}
  \]

• **Tyrosine**
  - Tyrosine is highly insoluble in water/serum phase in cheese
  - Therefore, it has a propensity to crystalise within the cheese matrix – this occurs in the later stages of maturation because it first requires proteolysis to have released tyrosine as a free amino acid
  - Once tyrosine has exceeded its solubility level, it will begin to form crunchy crystals
Decarboxylation of Amino Acids

- Histidine decarboxylase
  - Histidine → Histamine

- Tyrosine decarboxylase
  - Tyrosine → Tyramine

- Tryptophan decarboxylase
  - Tryptophan → Tryptamine

- Phenylalanine decarboxylase
  - Phenylalanine → Phenylethylamine

Free amino acid → Biogenic amine
Please let our experts help you to find the optimal and complete solution for your unique cheese and to get most out of your milk.

Differentiate by combining DVS® Cheddar cheese starter cultures with the perfect choice of coagulant, surface ripening, bioprotection and services from Chr. Hansen.

**COAGULANTS**
- CHY-MAX® Special or M
- CHY-MAX® SUPREME
- Microlant® classic
- Microlant® supreme

**RIPENING**
- DVS® CR adjuncts
- DVS® LH adjuncts

**BIOPROTECTION**
- FRESHQ
- BIOSAFE

**SERVICES/TOOLS**
- PhageWatch®
- Coagusens™
- TRIALS & SIX SIGMA
- EASY-DOSE™

Differentiate by combining DVS® Cheddar cheese starter cultures with the perfect choice of coagulant, surface ripening, bioprotection and services from Chr. Hansen.

To master texture and shelf life
To impart a unique flavor
To keep your final product great
Simply to stay ahead