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# Cheese yield and functionality

## The influence of coagulants and other enzymes

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# Content

1. Market opportunities

   Generate value in times with high customer demands

2. Small change, big difference

   How the choice of coagulant can have a big impact

3. Other enzymes

   An example of an enzyme to improve fat retention in the cheese

4. Sustainability

   Getting more out of milk not only benefits the dairy industry – it also lightens the industry's carbon footprint!

4. Combined solutions

   Take advantage of the full potential by combining the benefits from both cultures, coagulants and other enzymes



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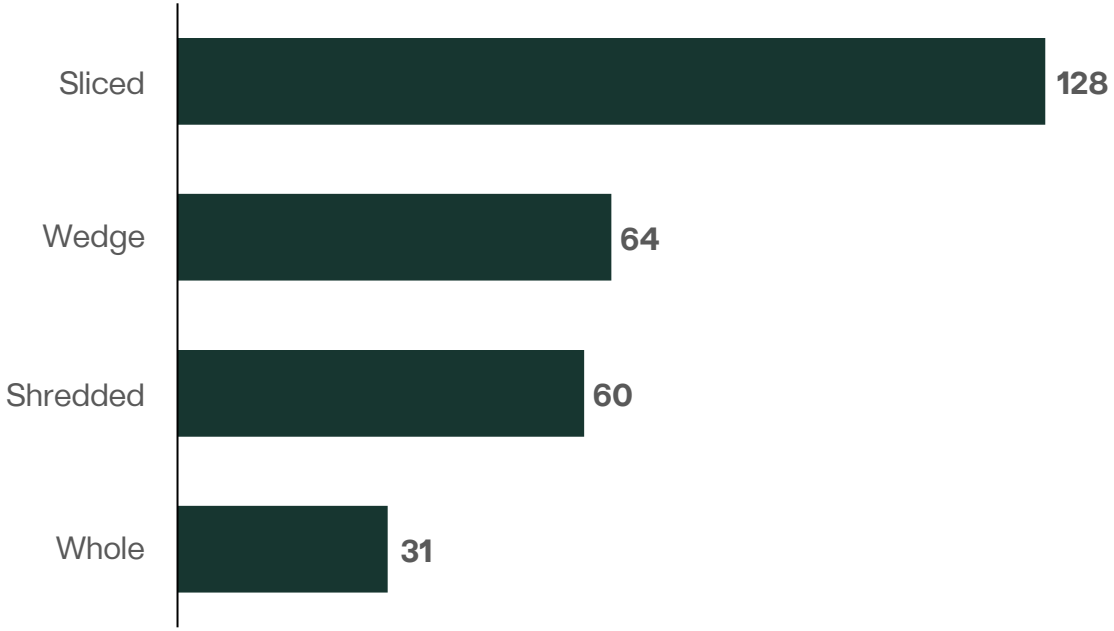
# Market opportunities

# Sliced and shredded cheese are growing formats that make convertibility and functionality more important than ever

Continental cheese is converted into many formats to cater to growing consumer demand for convenience and choice

## Continental cheese launches by format[1]

Total number (Europe), 2021




Cheese that is sold sliced or shredded is experiencing significant growth worldwide[2]

### Sliced

**€2.0** billion market growing at **3.3%** each year

### Shredded

**€4.4** billion market growing at **1.1%** each year

1 Mintel GNPD, 2022
2 IRI Market research, Global value by Retail Selling Price (RSP, Retailer)



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# Cheesemakers are under pressure to extract maximum value from their processes in a highly competitive market

Cheesemakers must continue to capture hidden pockets of value in their operations in order to meet growing demand from consumers and food service operators for tasty, authentic and convenient cheeses produced in more sustainable ways.

## Industry drivers

- High quality products
- Production efficiency
- Less waste



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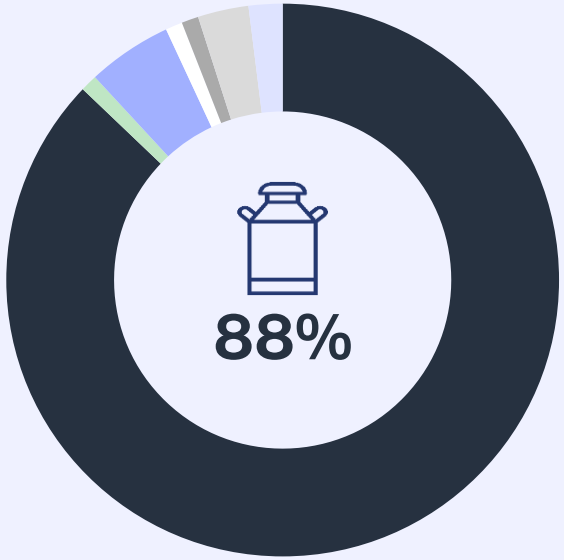
# Milk and labor are two of the most valuable resources when making cheese

**CHEESE PRODUCTION COSTS[1]**

Percentage of total cost




Milk
Packaging
Logistics
Energy
Culture & coagulant
Labor
Other (maint., QC)

## FOCUS ON MAXIMIZING VALUE

- About **93%** of the cost of producing cheese comes from milk (88%) and labor (5%)
- In addition to good hygiene, higher yields with lower proteolysis ensure that you **get the most out of your milk**
- The coagulant makes up only about 0.3% of total cost but can **make all the difference**

1 Data based on conversations with our global customers



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# We calculate yield from both an economic and moisture-adjusted perspective

## Economic

**Economic cheese yield (ECY) analysis can help you to:**

- Manage the productivity of the factory
- Improve profitability

$$\text{Cheese yield } \textbf{(ECY)} \ (kg/kg) = \frac{\text{Quantity of cheese } (kg)}{\text{Quantity of milk } (kg)} \times 100$$

To compare the cheese yield, the milk composition need to be the same (or take into consideration the fat and protein content)

## Moisture-adjusted

**Moisture-adjusted cheese yield (MACY) analysis can help you to:**

- Optimize the manufacturing process
- Extract more value from your raw material

The Moisture Adjusted Correct Yield (MACY) is sometimes fat- and salt-adjusted as well. You can also add the recovery coefficient to the MACY.

$$\textbf{MACY} = \textbf{(ECY) x} \ \frac{100 - \text{actual cheese moisture content}}{100 - \text{reference cheese moisture content}} \times 100$$

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# Unlocking the potential of coagulants

# The ideal coagulant

The ideal coagulant on the market is the one with the most specific proteolytic profile, enabling you to improve your productivity as well as your sustainability profile.

## Higher yield

Yield up to 1% more cheese (moisture-adjusted)

## Superior functionality

Optimize texture and reduce bitterness throughout shelf life, extending the window for conversion and improving convertibility

## Faster production

Process more milk and cheese in less time with faster and more precise coagulation

## Increased whey value

Keep more intact whey proteins and achieve a cleaner whey

1 Fermentation Produced Chymosin; compared to 2nd generation FPC market leading coagulant

# COAGULATION STEPS

**Coagulation time**

- **Flocculation time**
- **Hardening time**

- **Renneting** → **COAGULATION BEGINS**
- **Flocculation**
- **Cutting** → **COAGULATION ENDING**

## Maturation

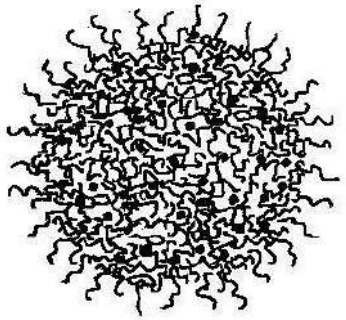
*Time scale*

- **PHASE 1 or PRIMARY PHASE**
- **GEL**
- **FIRMNESS**
- **WHEY OFF**
- **CLOTTING**
- **PHASE 2**
- **SYNERESIS**
- **CURD**

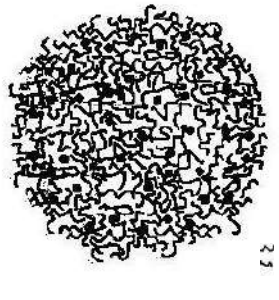
### Enzyme specificity

**Enzyme**

**Micelle casein**

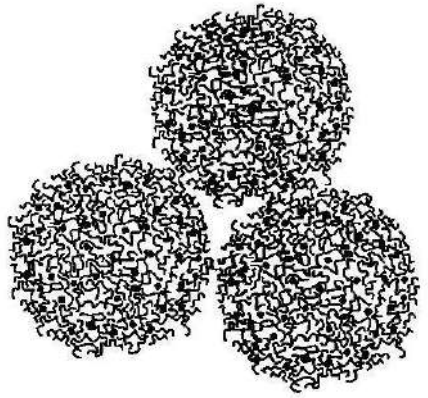


**Paracasein**

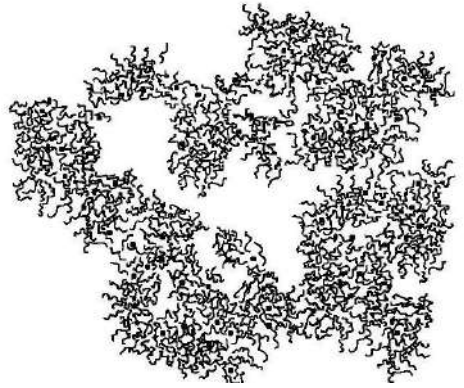


**CMP**

**HYDROLYSIS**



**AGGREGATION**





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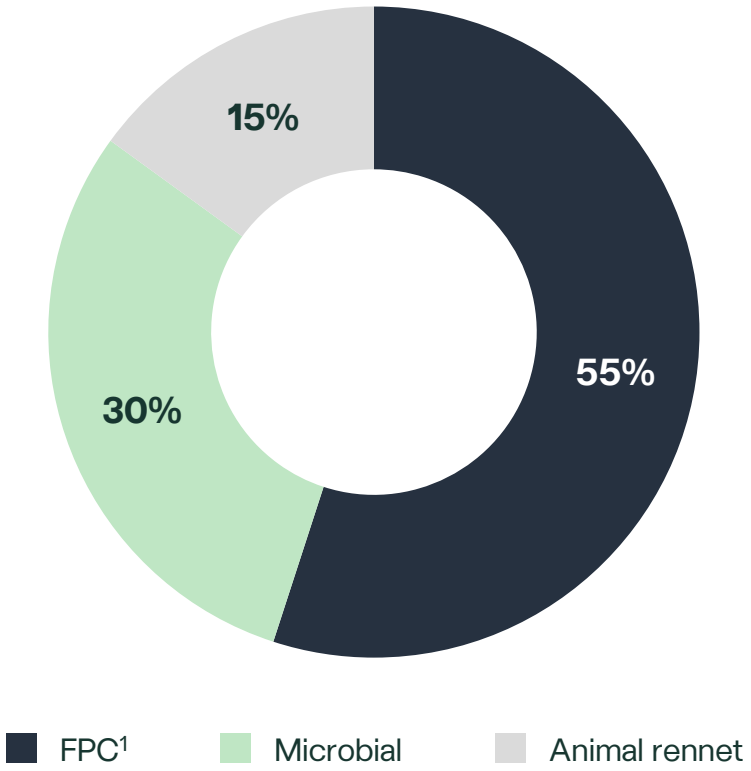
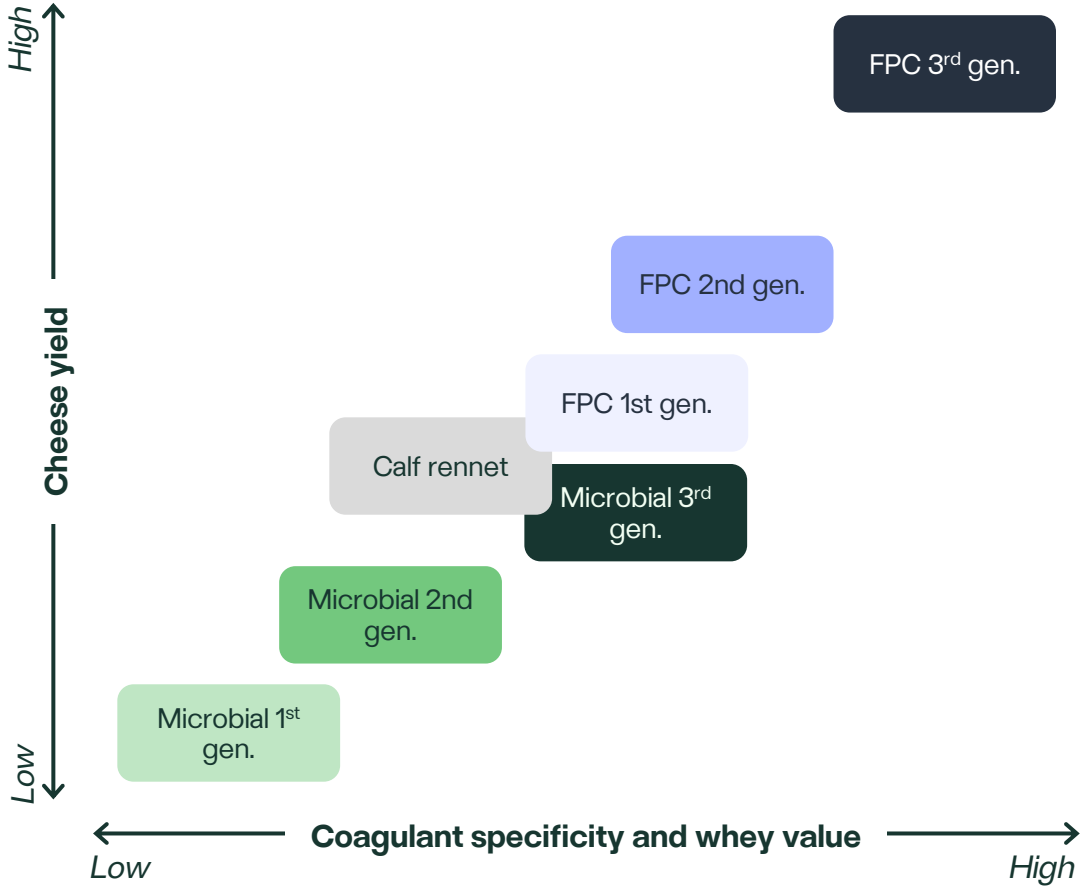
# How to choose between different types of coagulants

## Volume share of global coagulant use




1 Fermentation Produced Chymosin
Yield variates depending on the cheese process incl the temperature of pasteurization
Coagulant specificity is the ratio between desired and undesired protein breakdown. High specificity leads to firmer texture and reduced bitterness and vice versa.



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# Specificity and performance of the coagulants is described by their C/P-ratio

| The C/P ratio[1] | Casein substrate | Effect | Impact |
|---|---|---|---|
| C Clotting activity | κ | The higher clotting activity, the more precise cutting of kappa casein and ability to form a strong casein network | ▪ Use of a coagulant with a high C/P ratio results in a stronger casein network where fat and proteins are kept in the cheese<br>▪ Cheese yield is directly linked to the C/P ratio of the coagulants |
| P General proteolytic activity | α, β | The proteolytic activity affects the speed of breakdown of casein in bigger and smaller peptides (normally, fast speed leads to bitter taste) | |

1 C/P is the ratio between the specific clotting activity and general proteolytic activity.

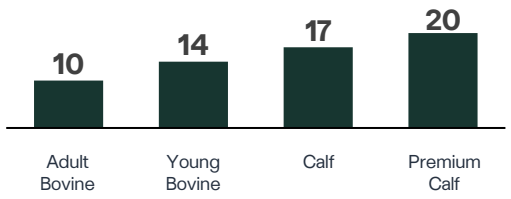
# FPC 3rd gen. brings the highest C/P ratio of coagulants on the market, enabling higher cheese yield and superior functionality

Reduced proteolysis results from a higher C/P ratio, indicating greater specificity during coagulation.

Specificity (C/P)[1]

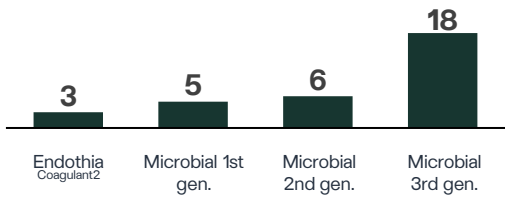
## ANIMAL

Keeping traditions alive



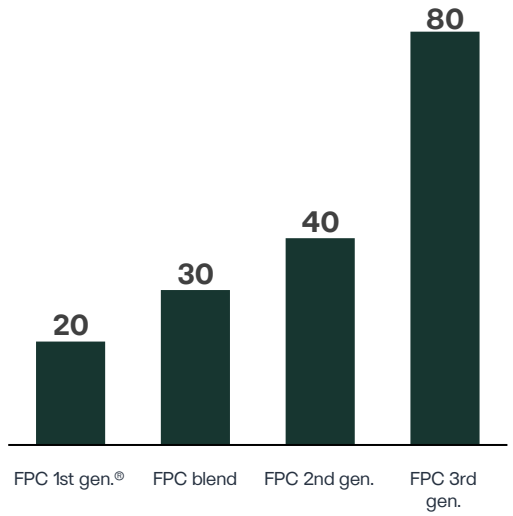

## MICROBIAL

Making organic possible




## FPC

For the modern cheesemaker




## FPC 3rd gen. delivers:

- The highest level of precision protein cutting during coagulation
- Excellent flavor comparable to FPC 2nd gen.
- Increased yield and functionality

1 C/P is the ratio between specific clotting activity (IMCU/ml) and general proteolytic activity
2 Thermolase is generally not compatible with organic cheese production



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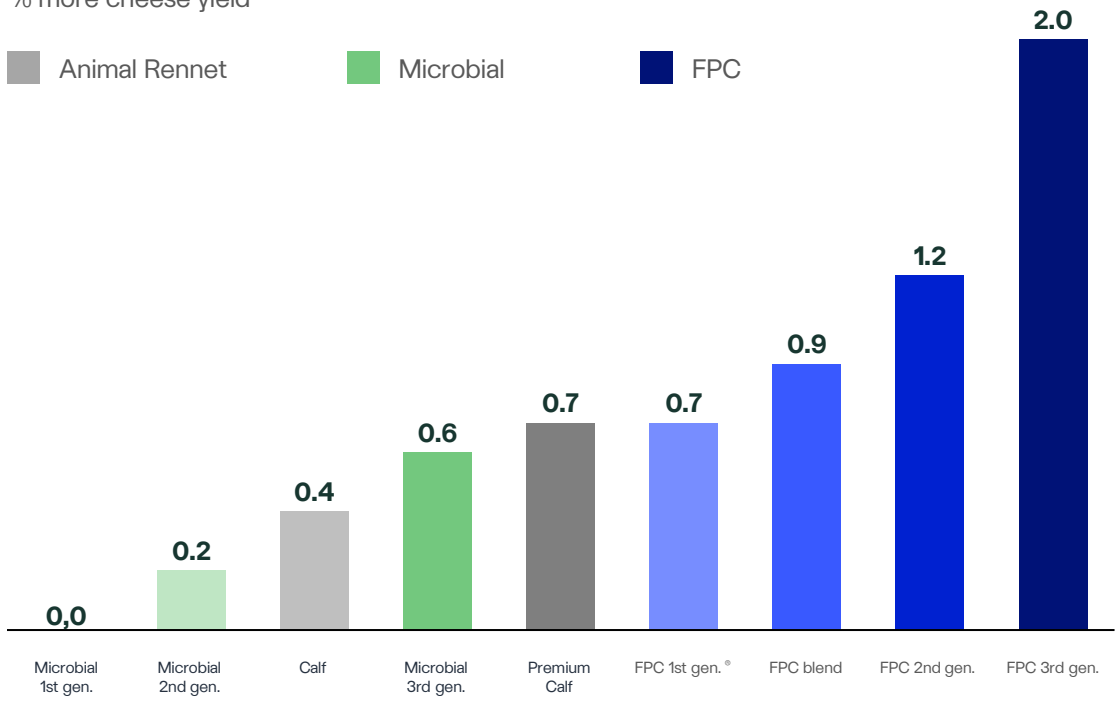
# Increased cheese yield

# FPC 3rd gen outperforms all other types of coagulants when comparing cheese yield

## Yield difference between different types of coagulants

% more cheese yield




Average moisture-adjusted cheese yield across coagulant ranges.
Yield difference may vary between cheese types, processes, milk quality.



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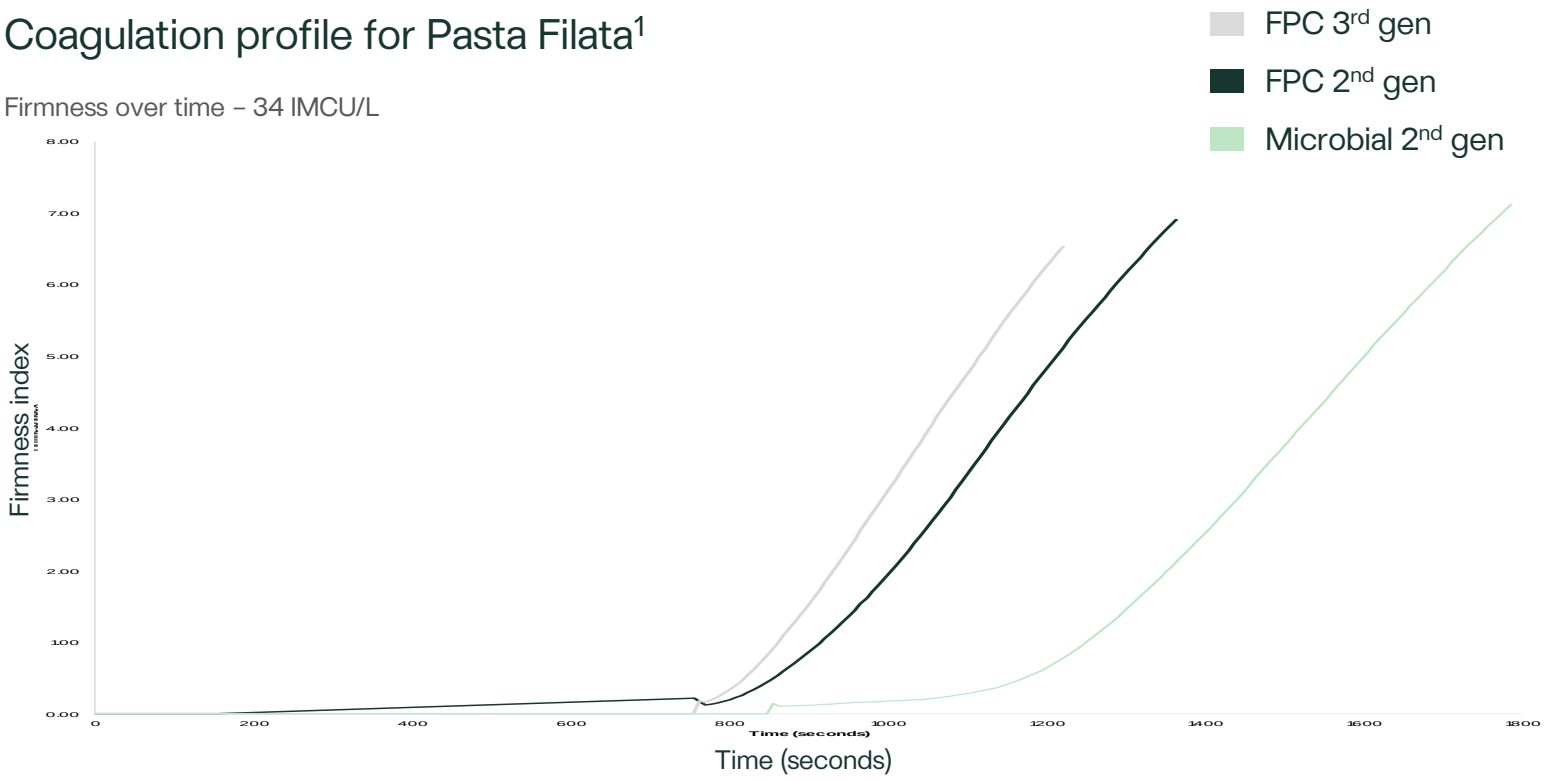
# Enhanced productivity

# Possible to reach the ideal firmness faster while obtaining maximum yield using coagulant with high C/P ratio

When dosed properly, FPC 3rd gen. can save production time and increase cheese yield

## Coagulation profile for Pasta Filata[1]




Renneting pH: 6.54
Protein: 3.35%

Fat: 2.30%
Renneting temperature: 34.5°C

### Same dosage – shorter coagulation

- The coagulation time using FPC 3rd gen. at same IMCU dosage is much faster than other coagulants in pasta filata
- Cutting the cheese curd at the same firmness to produce a cheese with similar characteristics is likely necessary. This allows for saving time in production

### Two options for cutting

- Due to higher speed of organization, FPC 3rd gen. is better able to contract the curd (more syneresis)
- Option 1: Cut at the same firmness using a softer cutting recipe
- Option 2: Cut with little higher firmness to compensate the syneresis effect



1 Customer trials, Aug. 2018

# What is the precision difference?

Faster coagulation means we can reduce the time by 5-10 minutes per vat

- That's **one extra vat** (about 2 tons) of cheese per day[1]
- or **2,5%** increased throughput

**It's a small change in the coagulant that can make a truly big difference – enabling fast and precise coagulation for the most efficient production**


1 Results based on global internal and customer trials.
2 Consumption stats: Bloomberg, 2017, https://bloom.bg/2j0zgxS. Yield increase depends on cheese type.

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# Optimized functionality

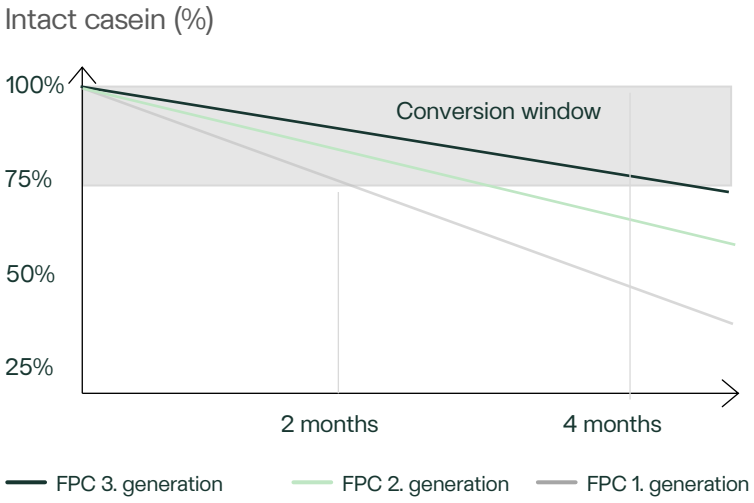
# Reduced proteolysis and slower protein breakdown

- Non-bitter flavor and firm texture throughout shelf life, extending the window for conversion and improving convertibility
- Less sticky cheese means less starch, paper dividers and giveaways
- Precise, thin slicing at higher speeds

# FPC 3rd gen increases shelf life and enables flexibility in converting your cheese

The cheese maintains a good machineability and conversion yield while also enabling the final product to last longer on the shelf.

## Protein breakdown index




## Shelf life

(when stored at 5°C)

| Cheese type | Shelf life with other market-leading coagulants | Extended shelf life with CHY-MAX® Supreme |
|---|---|---|
| Pasta filata | 2 months | 4 months = 100% |
| Cheddar | 2 months | 3 months = 65% |
| Continental | 2 months | 3 months = 65% |

FPC 3rd gen. stands out by slowing down the rate of casein degradation more than other market-leading coagulants. The stable cheese texture gives producers a longer window for converting the cheese (depicted as the grey area in the figure above).

**Customers who have tried FPC 3rd gen. have seen the following benefits:**

- Up to **40% fewer losses** during conversion
- Up to **30% less variation** on sliced weight, enabling improved packaging precision
- **Better texture** for thinner slicing, allowing you to get more out of less



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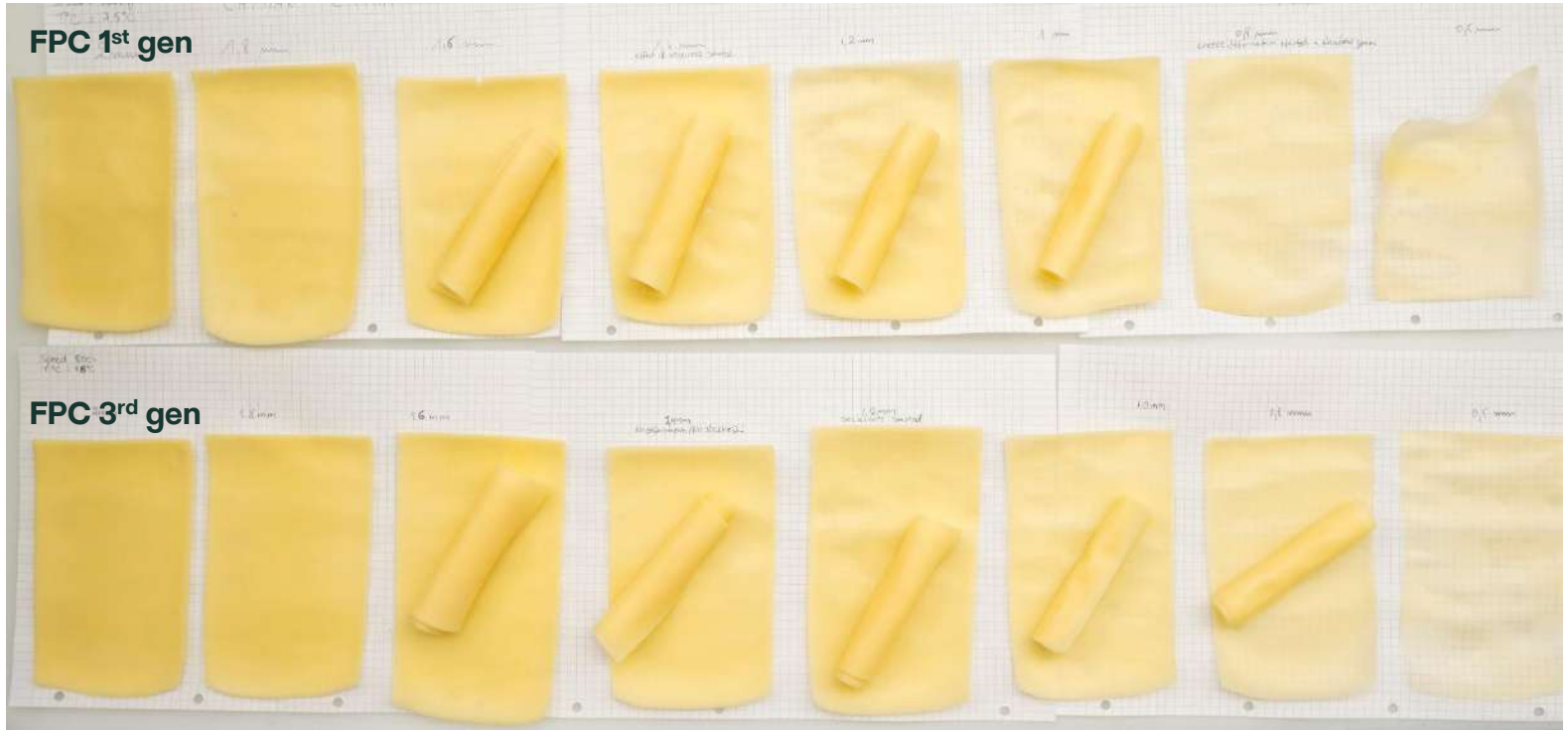
# FPC 3rd gen. demonstrates better performance during slicing

Continental cheese produced with FPC 1st gen and FPC 3rd gen sliced on a high speed slicing machine

Same force and same thickness applied




**Even during ultra-thin slicing, FPC 3rd gen. slices were:**

- More consistent
- More even
- Less deformed
- Less sticky

Customers confirm:

- Fewer complaints from end consumers with regards to stickiness
- Plastic or paper interleavers/dividers can potentially be removed between slices



Novonesis trial data: Slicing evaluation trials at Weber Inc., October 2018

# What is the functionality difference?

Faster slicing means thin slices with up to **10% more cheese** processed per day[1]

If you are slicing your cheese in an 8-hour shift, you can save over **45 minutes** and slice the same amount of cheese



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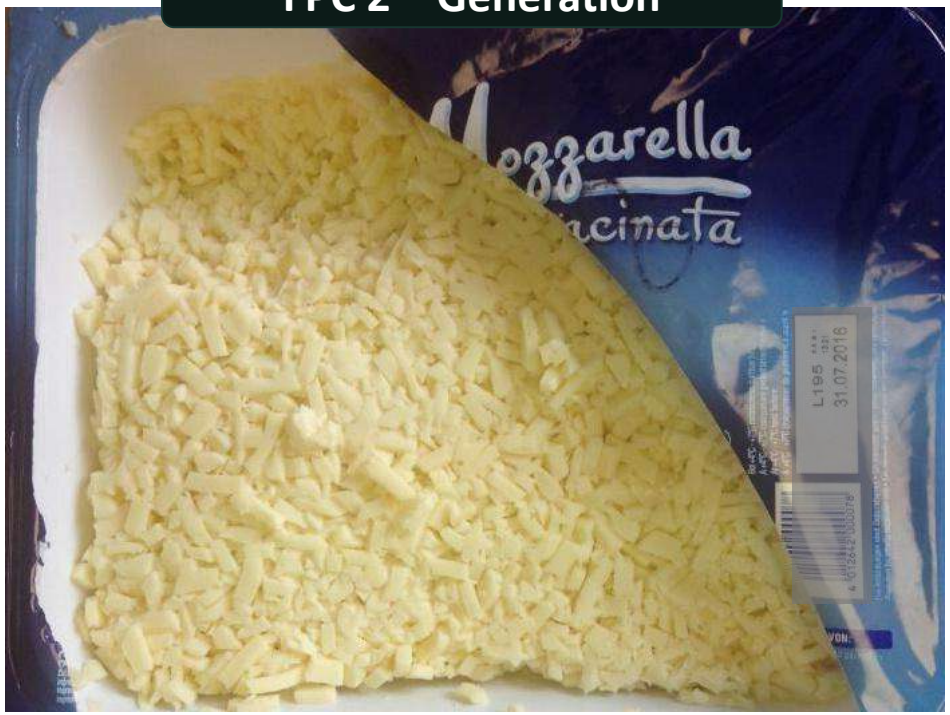
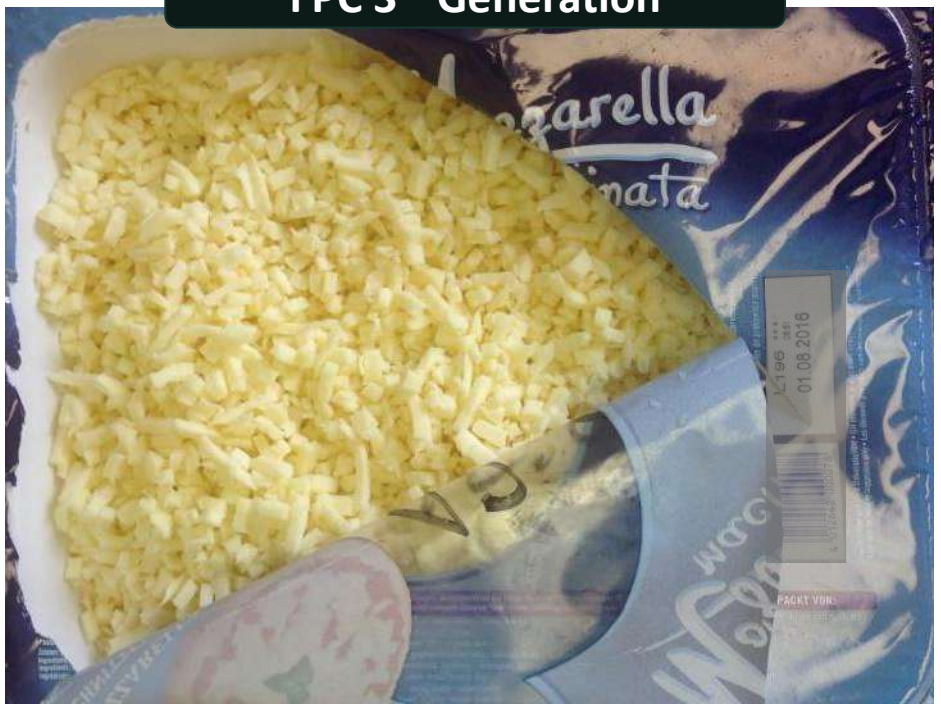
# Reduced proteolysis using FPC 3rd Generation

- Optimal texture for shredding and slicing
- Less softening during shelf life

**FPC 2nd Generation**




**FPC 3rd Generation**




Mozzarella 50% moisture
Stored 30 days at 5°C



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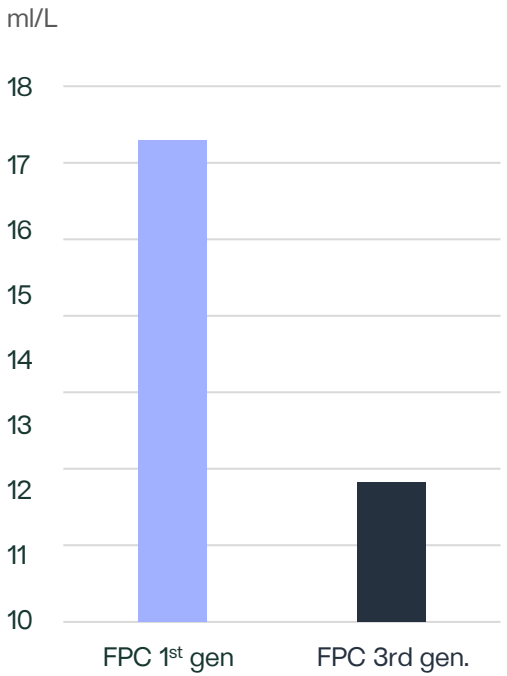
# Improved whey value

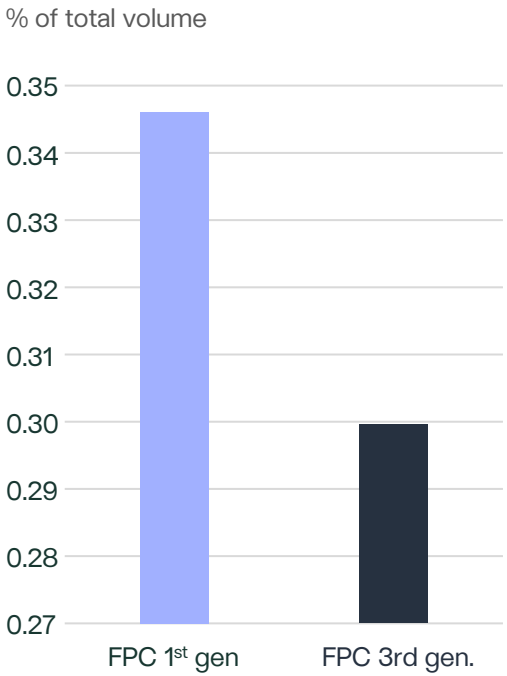
# Maintain your whey's value while reducing fines and fat

## Fines in the whey[1]




**-27% fines in the whey**

## Fat in the whey[1]



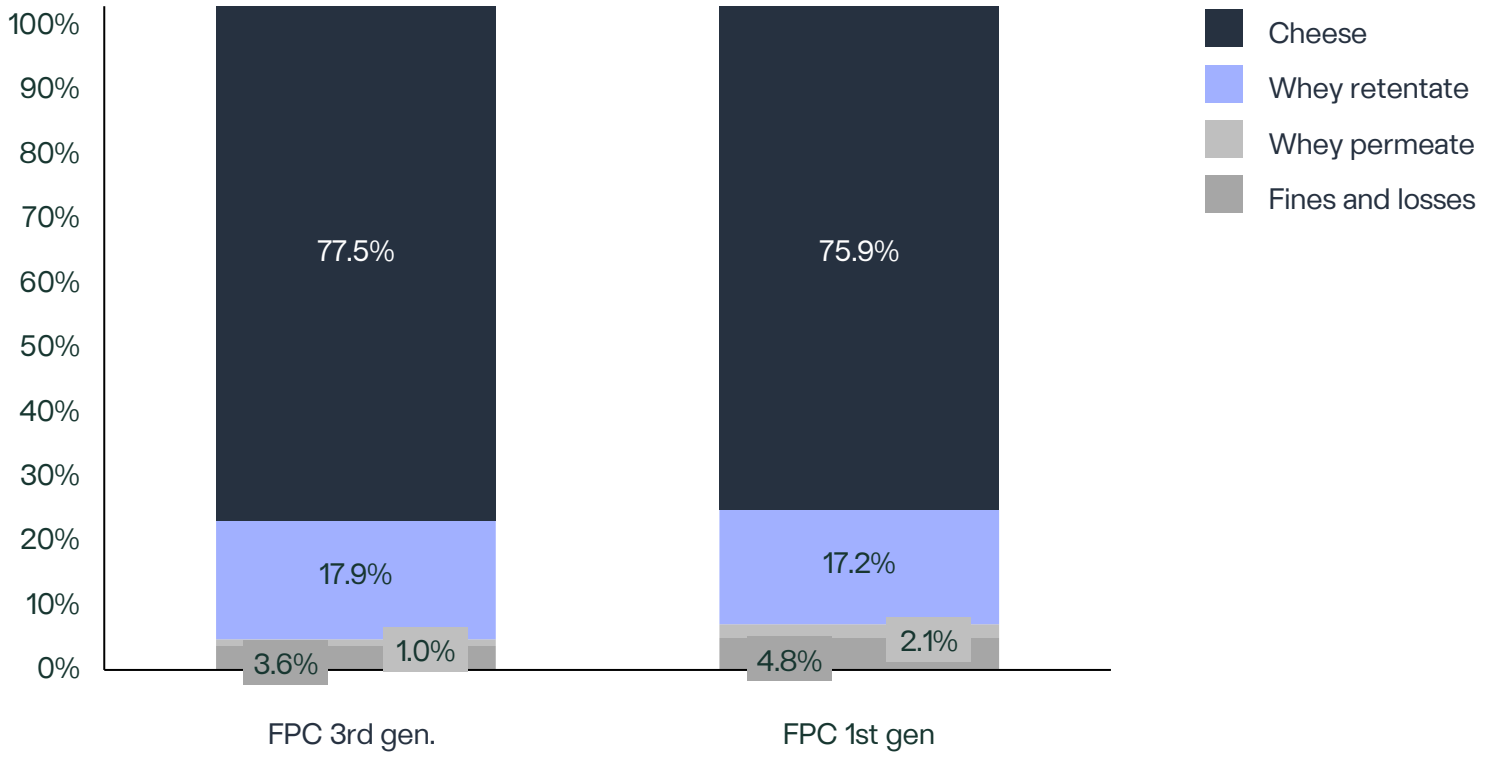

**-13% of fat in the whey**

1 Customer trial producing over 300 tons of continental type cheese



# Improved protein recovery in cheese and from whey

Split of protein in cheese and whey




## More Proteins with CHY-MAX® Supreme

- Total protein recovery (retentate and cheese):
  - FPC 3rd gen: 95.4%
  - FPC 1st gen: 93.1%
- Sum of non valuable protein (fines and losses and permeate)
  - FPC 3rd gen: 4.6%
  - FPC 1st gen: 6.9%

1 Study conducted by National Dairy School in France, 400 kg of whey, Maj 2019



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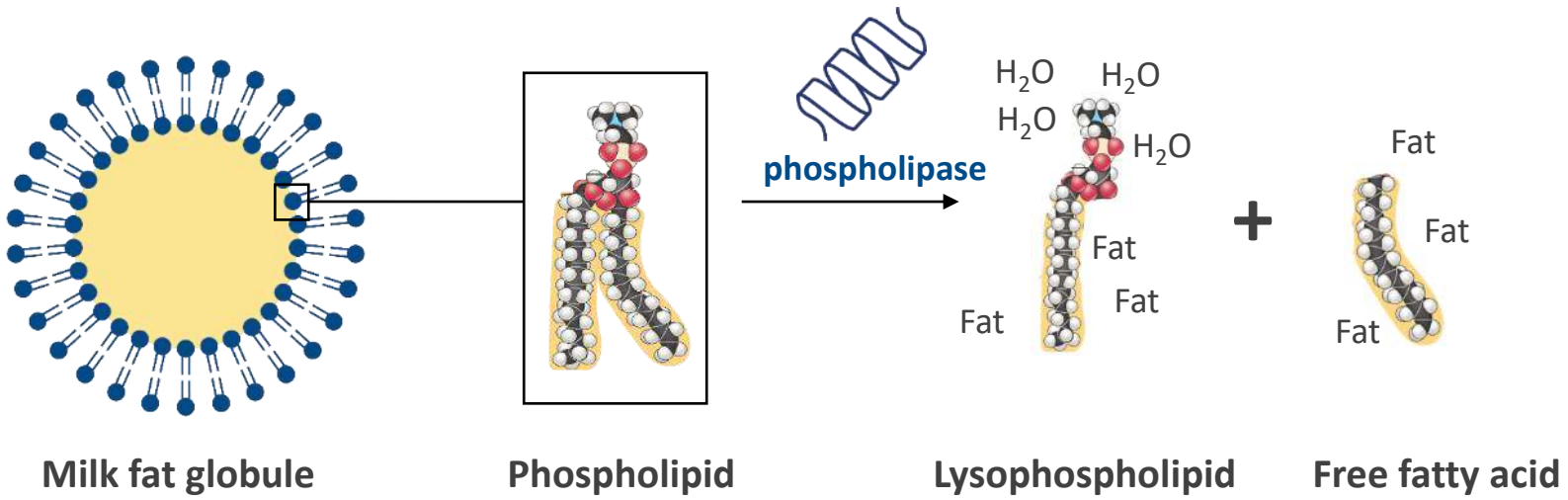
# Phospholipase, another type of enzyme

# Phospholipase

- The product is a standardized solution of a Fusarium venenatum phospholipase A1 produced by submerged fermentation with an Aspergillus oryzae strain.
- It acts by hydrolyzing ester bonds into lysophospholipids and free fatty acids




**INCREASES EMULSIFICATION PROPERTIES**

Increased water and fat retention in the curd results in higher cheese yield

The increased moisture retained in the cheese does not affect shelf life

**REDUCES COALESCENCE OF FAT GLOBULES**

Fewer fat losses during washing results in improved texture



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# The enzyme is added at least 20 minutes prior to the coagulant - no changes needed in the process

- Milk preparation
- **Acidification** ← **Phospholipase**
- **Coagulation** ← Rennet and coagulants
- Cutting and curding
- Scalding and stirring
- Draining and whey handling
- Specific cheese processing
- Ripening
- Packing and storage

Optimal temperature range of use 30 – 40°C



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# PL-A1 in real life

With PL-A1 Reference

- Yield increase 1,5% in a traditional Mozzarella production

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# What difference does improved yield and efficiency make on the planet?

# FPC 3rd gen. enables a sustainable cheese production

| | Sustainability benefit | FPC 3rd gen. feature |
|---|---|---|
| Fewer resources | Use less milk | Yield increase of up to 1%, enabling more cheese from the same amount of milk |
| | Save water and energy | Faster coagulation, decreasing production time due to high specificity |
| | Make better use of whey | More true whey proteins and fewer undesired protein fractions in the whey |
| Less waste | Reduce scrap during conversion | Firmer texture, improving sliceability and grateability |
| | Enable consumers to waste less | Reduced proteolysis, enabling the cheese to last longer on the shelf |
| | Use fewer plastic dividers | Firmer texture, reducing stickiness |

# What difference does a 2% higher cheese yield make from a sustainability perspective?

**300 kg less $CO_2$** would be emitted per ton of cheese. This is the equivalent to:

**$CO_2$** emitted to supply **electricity needs** of charging **38.500 mobile phones**[1]

Taking **1 passenger car** off the road for a **month**[1]

**What can a 2% yield increase do for you per ton of cheese you produce?**

You can get +20 kg more cheese per 8,000 liters of milk

**+20 kg cheese** =

62 € worth of cheese[3]

**8,000 kg milk**[2] saved to produce the same amount cheese

300 kg $CO_2$ saved

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Conversion from 1st generation FPC to FPC 3rd gen.
1 Greenhouse Gas Equivalencies Calculator | Energy and the Environment | US EPA. All references and calculations in speaker notes
2 Assumption 12.5KG Cheese of 100L milk
3 Cheese price for PF in Europe 3.10 EUR/kg August 2020



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# Combine solutions for optimal performance


On combining
FPC 3rd gen. coagulant with a moisture binding starter culture for pizza cheese:

“Even beyond improvements to profitability, we made better use of the fat content to waste less, improve sliceability, and yield a better end product.”

Eder Desconsi,
General Director at HE Brazil

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# Thank you