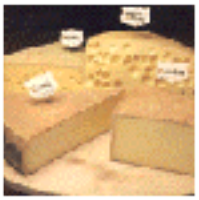

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Emmenthal Cheese Types

First revised edition, March 2002

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Emmenthal Cheese Types

First revised edition

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1. Introduction

Emmenthal cheese segment

This brochure is one of a series that has been produced to give you an overview of starter culture performance and modern manufacturing technology. It also provides a good insight into the experience and knowledge available to you as a partner of Chr. Hansen. For more than 50 years cheese-makers have turned to us to improve the quality of the food they make for people all over the world.

Our aim has always been to provide excellent products and we are aware that a product is only excellent when it gives the best results. One of the major reasons behind the success of Chr. Hansen's products is the partnership we establish with our customers. A continuing dialog ensures that our customers use the best products for their needs in the best way. This dialog is also a source of inspiration for new developments as the needs and requirements of our customers are the main driving force behind our R&D.

For nearly 130 years Chr. Hansen has worked to help food manufacturers offer high quality products.

From the beginnings with rennet, Chr. Hansen has grown into a full-range supplier for the dairy industry. Apart from a complete range of coagulants, the cheese-maker now has far greater flexibility and better control over his processes and products, thanks to Chr. Hansen colors, dairy cultures and enzymes – all from natural sources.

Chr. Hansen bridges the gap between traditional methods and the development and implementation of innovations, allowing people like you to concentrate on what they are best at – making cheese. For more information contact your local sales office or application center, there are more than forty in as many countries throughout the world.

Segment description	Typical examples	Scalding	Texture
Feta types	Feta, White cheese	max 35°C (95°F)	Semi-soft cheeses
Soft cheese types	Camembert, Brie, Argentine Port Salut, Crescenza, Gorgonzola	max 35°C (95°F)	Soft to semi-soft cheeses
Continental types	Gouda, Edam, Samsoe, Maasdammer/Leerdammer, Saint Paulin, Raclette, Manchego, Prato	35°C - 40°C (95-104°F)	Semi-hard cheeses
Cottage cheese types	Cottage cheese	22°C - 32°C (72-90°F)	Soft fresh cheese
Cheddar types	Cheddar, Territorials, American Cheddar, Monterey Jack, Colby	38°C - 42°C (100-108°F)	Hard cheeses
Pasta filata types	Mozzarella, Pizza cheese, Provolone,	37°C - 43°C (99-109°F)	Semi-hard to hard cheeses
Emmenthal types	Emmenthal, Gruyère	max 50°C (122°F)	Hard cheeses
Grana types	Grana, Parmesan, Sbrinz	50°C - 55°C (122-131°F)	Hard cheeses

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2. General characteristics of Emmenthal cheese types

Emmenthal (550,000 t/year) is the most common cheese in the Emmenthal cheese segment. The total volume of the segment is estimated to 850,000 tons per year. Europe is the main producer followed by the US.

Due to the high scalding temperature of the curd during processing they are also called "cooked cheeses" and can be characterized as being of "rennet" character, on an "acid to rennet" scale.

All Emmenthal cheese types are low in moisture, have propionate taste and generally long shelf lives.

Some of the general characteristics of the segment are listed as follows:

- Dry matter > 60 %
- Fat in dry matter 40–55% (46-47% is more common).
- Water content in fat free cheese < 55%
- Calcium in fat free dry matter > 2.9%
- pH 5.20 –5.40

Most of the cheeses are large (30–130 kg) with round or egg shaped eyes (1–4 cm in diameter).

The Emmenthal cheese types are used as table cheese or ingredients. In the case of the latter, grated cheese packing is increasing, and in some countries Emmenthal is widely used on pizzas.

Emmenthal cheese types

	Diameter and weight	Scalding	Eye formation	Salt %
Emmenthal France Germany US Switzerland	70-100 cm 30-100 kg	50-54°C (122-129°F)	1–2 cm	< 1% Brine
Gruyère France	40-60 cm 35-40 kg	50–57°C (122-135°F)	Few small eyes	>1.5% Brine or dry salting
Comté France	40-50 cm 35-40 kg	50–57°C (122-135°F)	Few small eyes	>1.5% Brine or dry salting
Beaufort France	30-70 cm 12-70 kg	50–57°C (122-135°F)	Few small eyes	>1.5% Brine or dry salting
Appenzeller Switzerland	20-30 cm 6-8 kg	42–46°C (108-115°F)	No eyes	>1.5% Brine
Sbrinz Switzerland	50-70 cm 20-45 kg	55–57°C (131-135°F)	No eyes	>1.5% Brine
Graviera Greece	30-40 cm 12-15 kg	48–50°C (118-122°F)	No eyes	>2.0% Brine

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3. Chr. Hansen ingredients for manufacture of Emmenthal cheese types

3.1 Cultures

The process for the manufacture of Emmenthal cheese types is characterized by two distinctive steps. First, acidification by lactic acid bacteria (LAB, primary cultures), and then fermentation by propionic acid bacteria (PAB, secondary cultures) during the ripening of the cheese.

In the tables below the different cultures are given and the function they have in the production of Swiss cheese types.

Primary cultures

Strain name	Function in Swiss cheese production	Growth condition
Lactococcus lactis subsp *lactis* *Lactococcus lactis* subsp *cremoris* *Lactococcus lactis* subsp *diacetylactis* *Leuconostoc cremoris*	Pre-ripening of the milk. Proteolysis in cheese. Cheese flavor.	Can grow until 40°C (104°F)
Streptococcus thermophilus	Production of lactic acid (mostly D-) during the first hours of production.	Grows from 30 – 50°C (86-122°F)
Lactobacillus helveticus	Production of lactic acid (L- and D-). Consume remaining sugars. Proteolytic activity.	Grows from 30 – 50°C (86-122°F)

Remarks

Lactobacillus lactis can be used and has the same role as *L. helveticus*. It is less sensitive to high cooking temperature and acidifies earlier than *L. helveticus*.

Secondary cultures

Strain name	Function in Emmenthal cheese production
Propionibacterium freudenreichii subsp. *shermanii*	Fermentation of lactic acid (lactate) to propionic and acetic acid (ratio 2:1) and CO_2 Production of proline for taste Lipolytic activity Grows in warm room during ripening

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3.1.1 Direct Vat Set (DVS) cultures

Direct Vat Set (DVS) cultures for direct inoculation of the process milk have made a significant impact on modern cheese-making operations across the world. DVS cultures for cheese were introduced in the early 1980's and are now able to compete head to head with bulk starter cultures. The reasons behind the growth in the use of DVS cultures are based on a number of benefits that these systems offer to the cheese-maker. The key benefits are:

Convenience

* with DVS the cheese-maker does not have to prepare bulk starter in the dairy and can concentrate on making cheese.
* no bulk starter production means less risk of phage contamination leading to slow or lost vats and downgraded cheeses.
* with a range of phage unrelated cultures, our DVS can always provide a back-up culture.

Product consistency

* ability to use DVS cultures in special combinations producing different cheese types and cheese flavors without the need for additional bulk starter facilities.

Flexibility

* the DVS culture can be used as it is required in the dairy, so there is no bulk starter waste either from over production or losses in the system.
* the dairy manager does not have to worry about bulk starter preparation at the week-end, the DVS culture can be used directly from the freezer on Monday mornings.

Safety

* the DVS culture is fully tested for activity and microbiological contaminants before it leaves Chr. Hansen, and certificates of analysis can be provided to support this if required.

** Standardized DVS cultures activity means consistent acid production and performance in the vat. This in turn can result in Swiss cheese with more constant fermentation and better-controlled ripening/eye formation.*

Picture : Chalon Megard

Traditional Emmenthal cheese vat

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3.1.2 Product range primary cultures

Name	Type	Form	Item number	Size
ST-B01	*S. thermophilus* (LAB)	FD-DVS F-DVS	100113 100183 100210 5011692	50 U 200 U 500 U 500 g
AP-15	*S. thermophilus* (LAB)	F-DVS		500 g
ST-M3	*S. thermophilus* (LAB)	FD-DVS F-DVS	100471 617674	200 U 500 g
ST-M4	*S. thermophilus* (LAB)	FD-DVS F-DVS	100472 617675	200 U 500 g
LH-32	*Lactobacillus helveticus*	F-DVS	70781	250 g
LH-B01	*Lactobacillus helveticus*	F-DVS	501698	500 g
LH-B02	*Lactobacillus helveticus*	FD-DVS FD-DVS FD-DVS F-DVS	100116 100185 100213 501699	50 U 200 U 500 U 500 g
PS-1	Propionic acid bacteria (PAB)	FD-DVS FD-DVS F-DVS	100117 100118 501579	2 U 5 U 500 g
PS-2	Propionic acid bacteria (PAB)	F-DVS	501580	500 g
PS-4	Propionic acid bacteria (PAB)	FD-DVS F-DVS	100121 501582	5 U 500 g
APM-1	*Streptococcuc lactis* subsp. *lactis/cremoris*, *Lactobacillus helveticus*, *S. thermophilus*	FD-DVS	616880 616881 616882	50 U 200U 500 U

Process parameters have a major effect on the development of LAB and PAB. This range has therefore been carefully selected.

This choice and the eventual interaction between LAB and PAB will be described and explained in section 4.

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3.2 Coagulants

Chr. Hansen is able to supply a full range of coagulants. It is within this particular segment that we have our longest track record, supplying rennet for over 125 years. Today, grown according to your requirements, we have adapted our range to fit your needs, linking tradition with research and innovation:

Chr. Hansen's coagulant range:
NATUREN® : Animal rennet (calf and/or bovine)
CHY-MAX® : Chymosin produced by fermentation
MICROLANT™ : Microbial coagulants

These three groups have varying characteristics with regard to proteolytic activity, heat lability and sensitivity to changes in pH, temperature and $CaCl_2$. Traditionally, calf rennet has been regarded as the ideal cheese coagulant because of its highly specific milk clotting activity. CHY-MAX® shares this characteristic and is rapidly winning ground all over the world to be the preferred choice of the cheese-maker.

The last two groups, CHY-MAX® and Microlant™ are approved for use in kosher, halal and vegetarian products. CHY-MAX® is also available in a kosher quality approved for Passover, opening up opportunities for you.

Furthermore, we can demonstrate the effect each of these coagulants has on your yield. Not necessarily by more than a fraction of a percentage point but enough to make a measurable impact to the bottom-line result for your business. You should, for example, be able to achieve an improvement of around 0.5% in yield by switching from a microbial coagulant to our very specific CHY-MAX or to a High Chymosin Naturen type.

Being a full-range supplier we can give you objective advice designed to achieve the optimal solution for your particular process. But optimization of production is not simply a question of enhancing the yield from a specific quantity of milk.

The characteristics of the end product are at least as significant. For instance, side activity is an important issue, particularly when your cheese or whey is used as an ingredient in other products.

Whey is often a significant additional source of profit in cheese-making. Highly nutritious, it is a valuable ingredient in a broad range of foods. However, for whey of the right quality to be achieved, it is important to select precisely the right coagulant for your cheese-making.
Consistent clotting activity, specific proteolytic activity, side activity, yield, maturation, flavor and texture, whey, certification, all in all there are over 30 interactive parameters to be taken into consideration when choosing the right coagulant. It is a complicated jigsaw but we offer you our expertise to help you solve it.

From the sourcing of raw materials to on-time delivery at your doorstep, our commitment is driven by your requirements.

The following information is important to consider before choosing which coagulant to use for Emmenthal cheese production.

In Emmenthal cheese, coagulant has been widely reported to be inactivated by the high scalding temperature 50–55° C.

Consequently, the coagulant has no effect on final cheese properties and characteristics.

Only legislation and specific coagulation characteristics have to be taken into account when choosing the coagulant for Emmenthal cheese.

Due to high renneting pH and specific cutting techniques, only CHY-MAX, NATUREN and THERMOLASE are recommended in Emmenthal cheese (see section 3).

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3.3 Other ingredients

Lysozyme

Lysozyme is an enzyme extracted from egg white. This enzyme is classified as a food additive according to EU/89/107 as E1105.

Lysozyme prevents the swelling of the Emmenthal cheese type by inhibiting the growth of *clostridium tyrobutyricum*. The enzyme acts on the cell walls of the vegetative form of the bacteria.

Lysozyme is added in the cheese vat after heat treatment and before renneting at an average rate of 25 g per 1000 l.

Lysozyme is available in liquid or granular form.

Picture : Chalon Megard

Emmenthal cheeses leaving ripening room

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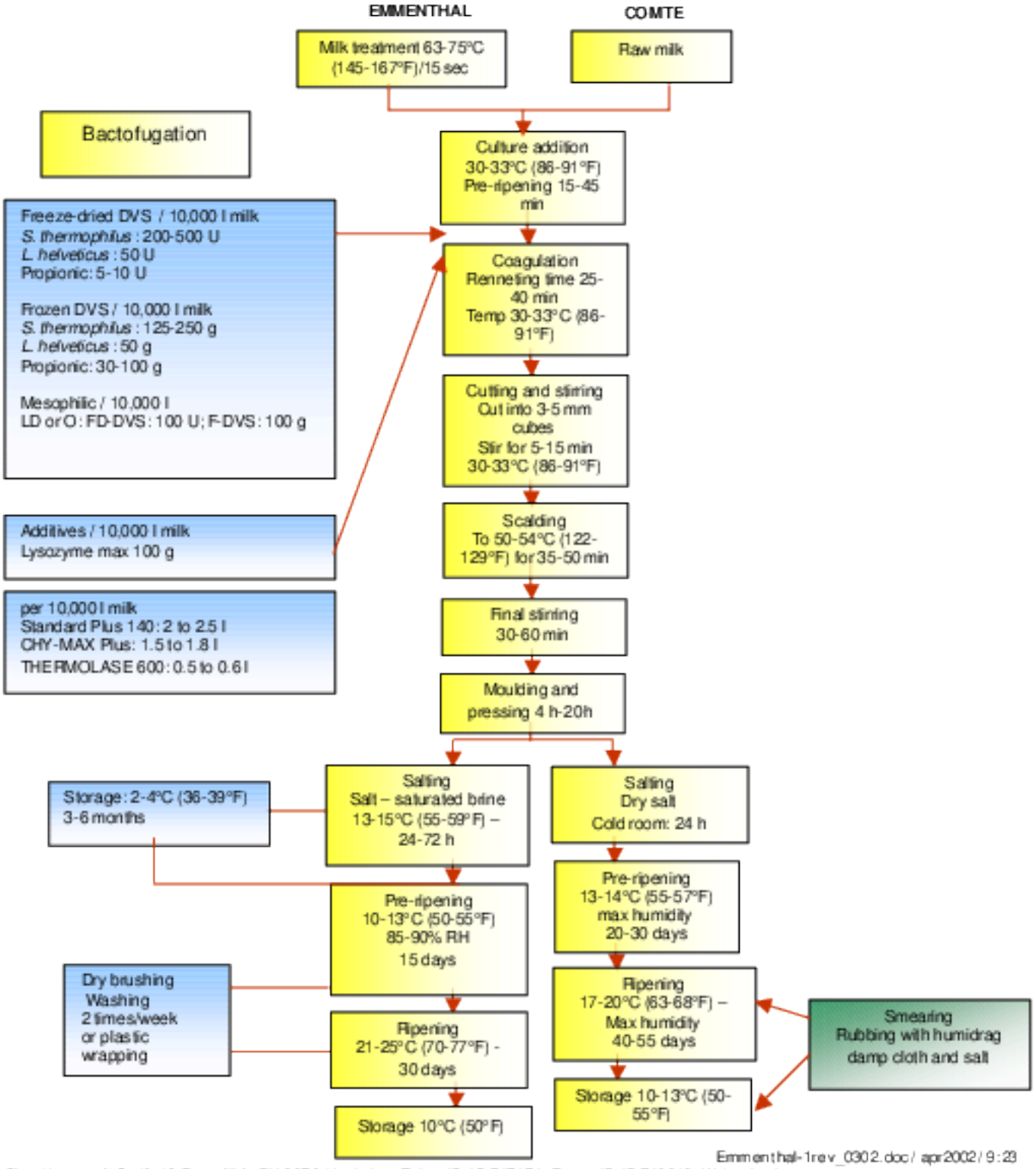
4. Production procedure

4.1 Typical cheese manufacturing process



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4.2 Critical manufacturing points

4.2.1 Milk treatment

Emmenthal cheese types are mainly produced from pasteurized milk (or thermized milk) and sometimes raw milk.

Gruyère and other DOP (Defined Origin Production) cheeses are made from raw milk. In modern Swiss type cheeses, heat-treated milk and even UF concentrated milk can be used.

Bactofugation lowers the number of spores (Cl: *tyrobutyricum*) having an impact on eye formation.

4.2.2 Culture addition

- Mesophilic cultures (*Lactococcus lactis* subsp *cremoris*) play a role at the starting point of cheese-making by boosting, *Streptococcus thermophilus* and furthermore at cheese ripening due to their proteolytic activity. (They are no longer viable after the scalding process).
- *Streptococcus thermophilus* (ST Galactose negative) is the main player in the acidification process. The rate of inoculation is low because wheying off must precede acidification in Emmenthal cheese to ensure the "rennet character".
- To monitor acidification speed, the pH is measured after 2 and 4 hours of molding.
- *Lactobacillus helveticus* finishes the acidification process, consuming the remaining sugars (lactose and galactose). In Emmenthal manufacture it is very important not to have any sugars left after 24 hours. It also influences the growth of PAB and the proteolysis in the cheese (see further). The rate of inoculation is low.
- Propionic bacteria. When using raw milk these occur naturally whereas with pasteurized milk they must be added. In Emmenthal cheese the rate of inoculation is low. PAB play a major role during ripening for eye formation and taste.

4.2.3 Renneting

As a high renneting pH (6.6) results in a weak coagulum, it is preferable to use THERMOLASE, NATUREN or CHY-MAX for Emmenthal cheese.

Usually the clotting time is between 20 and 30 minutes.

4.2.4 Cutting – First stirring

Cutting is a key parameter in Emmenthal cheese because of the small size of the curd (3-5 mm) that is required. To reach this size, cutting must start when the coagulum is still soft.

The technique of cutting three times is often used (cutting with rest times).

Also the duration of first stirring time (5-15 mins) influences acidification speed.

4.2.5 Scalding – Final stirring

Speed of cooking the whey-curd mixture is important. Speeds that are too rapid or too slow (associated with a rapid acidification) can lead to the case-hardening of the curd, which can hamper whey removal. (1°C (34°F) / 2 mins) at the final stage of scalding is used).
The final temperature of processing in the vat (50-54°C) (122-129°F) and the stirring time after cooking determine the cultures remaining in the curd.

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Consequently these parameters influence acidification and the characteristics of the end product (mesophilic cultures are destroyed, *S thermophilus* are slowed and *L. helveticus* are favored).

4.2.6 Molding –Pressing –Returning

It is important to reduce air inclusion during molding. This has an effect on eye formation (number, size). Most modern Emmenthal cheese factories mold under vacuum. In this way, the number of eyes is reduced and their size is increased.

Pressure on the cheeses must be progressive and uniform. The object of re-turning the molded curd is to improve curd homogeneity (moisture distribution). With modern equipment where vacuum is used, re-turning becomes unnecessary.

As most of the acidification takes place during pressing, it is important to control the pH. 15-25° Dornic (TA 0.17-0.25%) is reached two hours after molding and likewise 35-45° Dornic (TA 0.40-0.50%) is common 4 hours after pressing.

Remarks:
The modern trend is to reduce the time for pressing and before brining. In Emmenthal cheese it is important to complete sugar consumption, keeping the acidification time to a minimum (traditionally 20 hours).

Picture : Chalon Megard

4.2.7 Salting

According to the type of cheese, the pH before salting will be 5.2- 5.4.
The residence time (24-72 h) in brine depends on the weight of the cheese, the target being to get a salt level in the cheese from 0.6-0.8%(Emmenthal) to 1.5%(Comté).

4.2.8 Ripening

Propionic fermentation is a phenomenon unique to Emmenthal cheese production. It consists of fermentation of lactate:

3 lactate $\rightarrow$ 2 propionate + 1 acetate + 1 CO_2.

PAB contribute to the ripening in different ways:

- Responsible for eye formation: CO_2 produced.
- Great effect on taste of the finished cheese: propionic acid, acetic acid, proline produced.
- Slightly lipolytic.
- Inhibits the growth of several unwanted bacteria.

This fermentation takes place in the warm room and depends on several factors (see sect. 4).

The eye formation will depend on the level of CO_2 produced and the ability of the cheese to keep the gas inside the cheese. The number and location of the eyes depends on the presence of weak points

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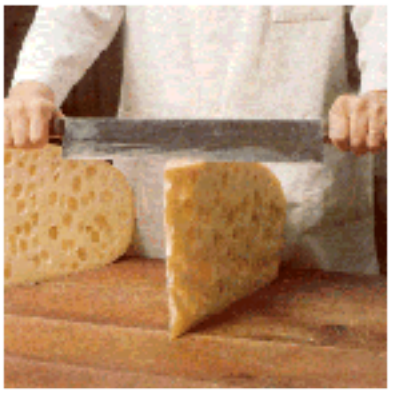
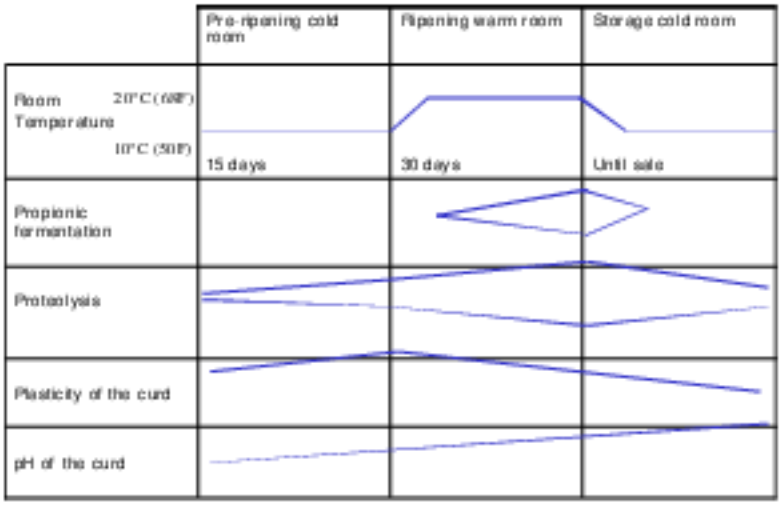
in the curd that will permit and encourage the collection of sufficient gas to form eyes. Another important factor is the texture of the cheese for the 'quality' of the eyes.

In this context it is important to remember that other phenomena beside propionic fermentation (even if less important) such as proteolysis, plasticity and pH of the curd are as important for the characteristics of the finished cheese (see table below).





The skill of the Emmenthal cheese-maker consists of mastering all these parameters using different ripening conditions (temperature, CO_2 concentration, humidity, time in cold and warm rooms) in order to get the required cheese. (Number, size, shape of eyes as well as taste and texture).

Remarks:
Besides propionic fermentation, it is known that, even if unwanted, butyric fermentation (*C tyrobutyricum*) plays an important role in Emmenthal ripening. (Eyes and taste. See last section).

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Examples of Emmenthal cheese ripening

	1. Room	2. Room	3. Room
Emmenthal France, Germany Switzerland	10-13°C (50-55°F) 2-3 weeks	20-24°C (68-75°F) 2-3 weeks	10-13°C (50-55°F) 8-12 months
Gruyère France	10°C (50°F) 3 weeks	15-20°C (59-68°F) 2-3 weeks	12-15°C (54-59°F) 8-12 months
Comté France	10-13°C (50-55°F) 3-4 weeks	17-20°C (63-68°F) 6-8 weeks	10-13°C (50-55°F) 2 months
Beaufort France	10-14°C (50-57°F) 6-18 months		
Appenzeller Switzerland	12-15°C (54-59°F) 5-6 weeks 90-95%RH	10-14°C (50-57°F) 4-6 months	
Sbrinz Switzerland	16-18°C (61-64°F) 3-6 weeks	10-12°C (50-54°F) 15-20 months	
Graviera Greece	15-18°C (59-64°F) 3-4 weeks	12-14°C (54-57°F) 3-5 months 85-90°C (185-194°F) RH	

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5. Culture characteristics relevant to Emmenthal cheese production

The following data explains the selection criteria for the range in this segment, and allows cheese-makers to choose the most appropriate culture.

The primary cultures (LAB) have been tested in our laboratory under conditions simulating Emmenthal cheese-making. Thus the ITG* temperature profile, which is a reference for LAB test in Emmenthal, has been used.

Furthermore other LAB functions determining the characteristics of the curd before brining should be measured (post-acidification, residual acids and sugars).

* Institut Technique du Gruyère (Technological Gruyère Institute).

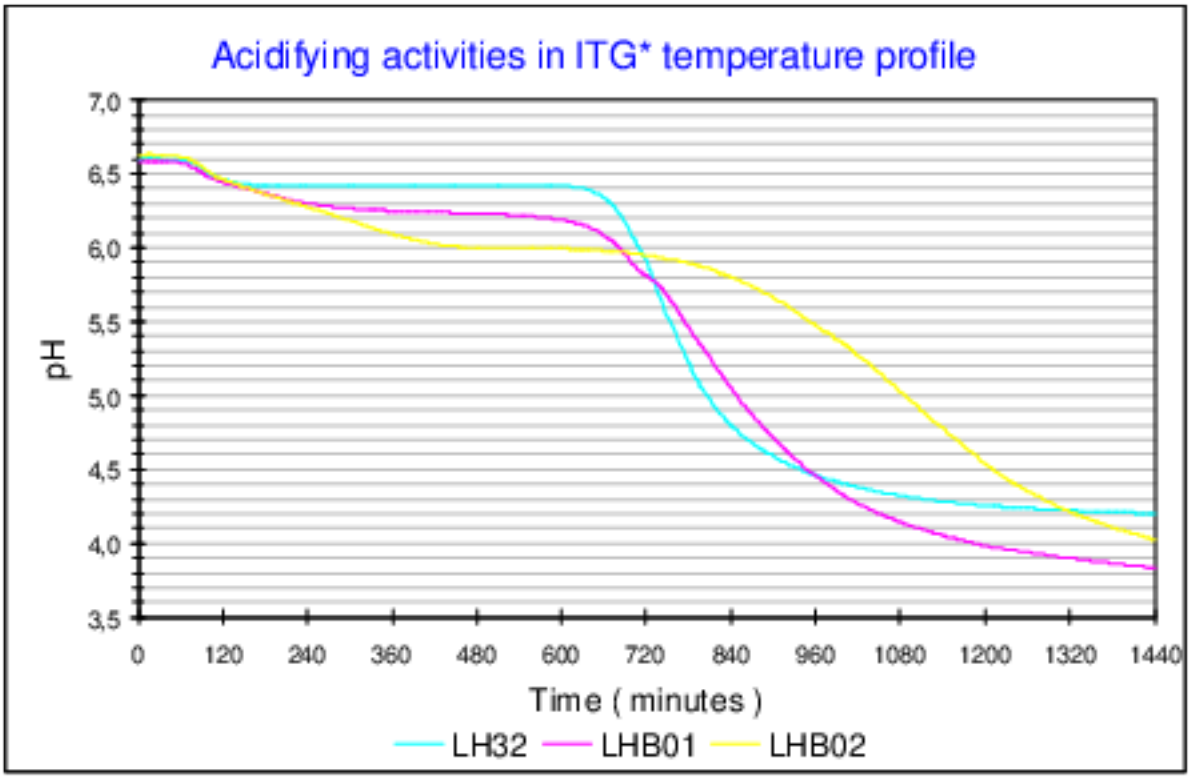
Secondary culture (PAB) should be tested under relevant conditions for Emmenthal cheese ripening, which are partly the result of the first fermentation such as:

- pH
- Salt
- Lysozyme
- Temperature
- Nitrate

It should be noted that metabolites (lactic acid) produced by the first fermentation influence the growth of PAB, ((L+) Lactate being fermented faster than (D-) Lactate).

Finally, tests showing the interaction between LAB and PAB should be carried out.

5.1 Technical information on *Lactobacillus helveticus*



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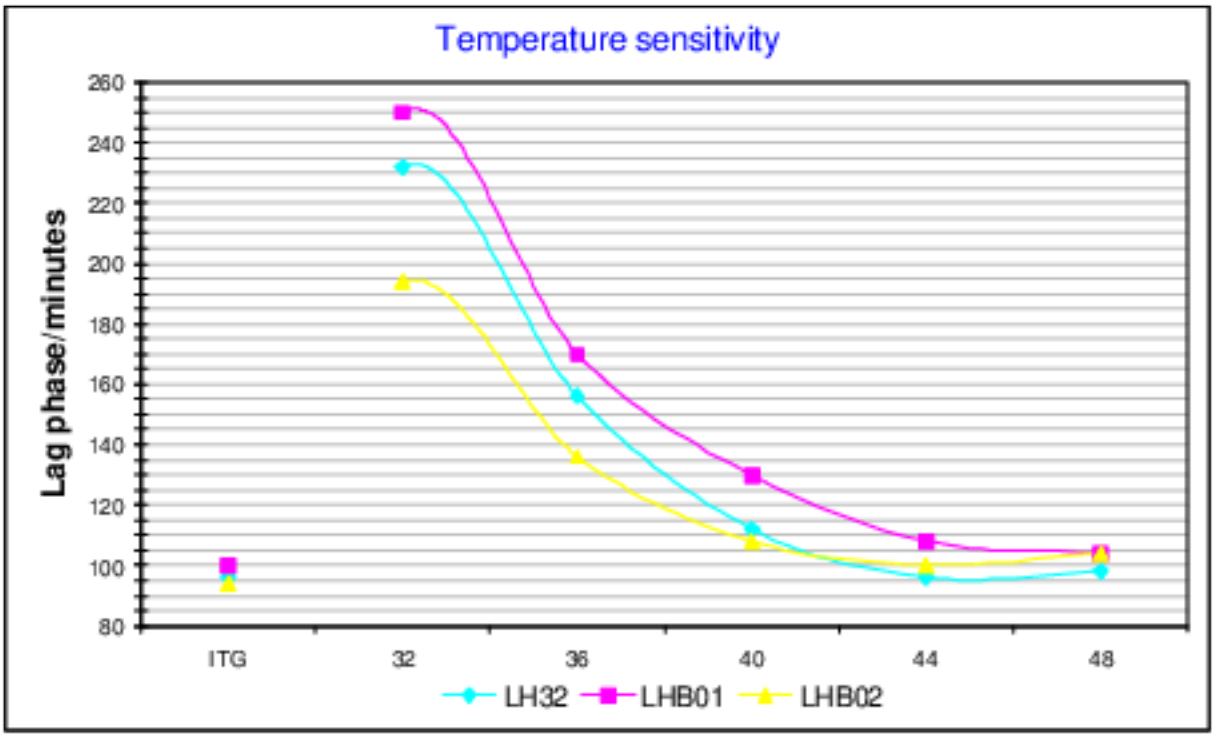

Lag phase, time to reduce milk pH by 0.08 pH units.

Post-acidification at 40°C (104°F) :	
	pH16h
LH-32	3.77
LH-B01	3.42
LH-B02	3.39

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Acid and sugar dosage on fermented milk by HPLC

	LH-32		LH-B01		LH-B02	
	40°C (104°F)	ITG*	40°C (104°F)	ITG*	40°C (104°F)	ITG*
Citric acid	1.7	1.9	1.4	1.7	2	1.9
Lactic acid	11.1	6.6	18.3	11.4	18.7	8.4
Acetic acid	0.2	0	0.8	0.2	0.9	0
Lactose	28.5	30.6	17.6	27	27.1	35.4
Galactose	6.4	8	1.9	3.6	1	2.1

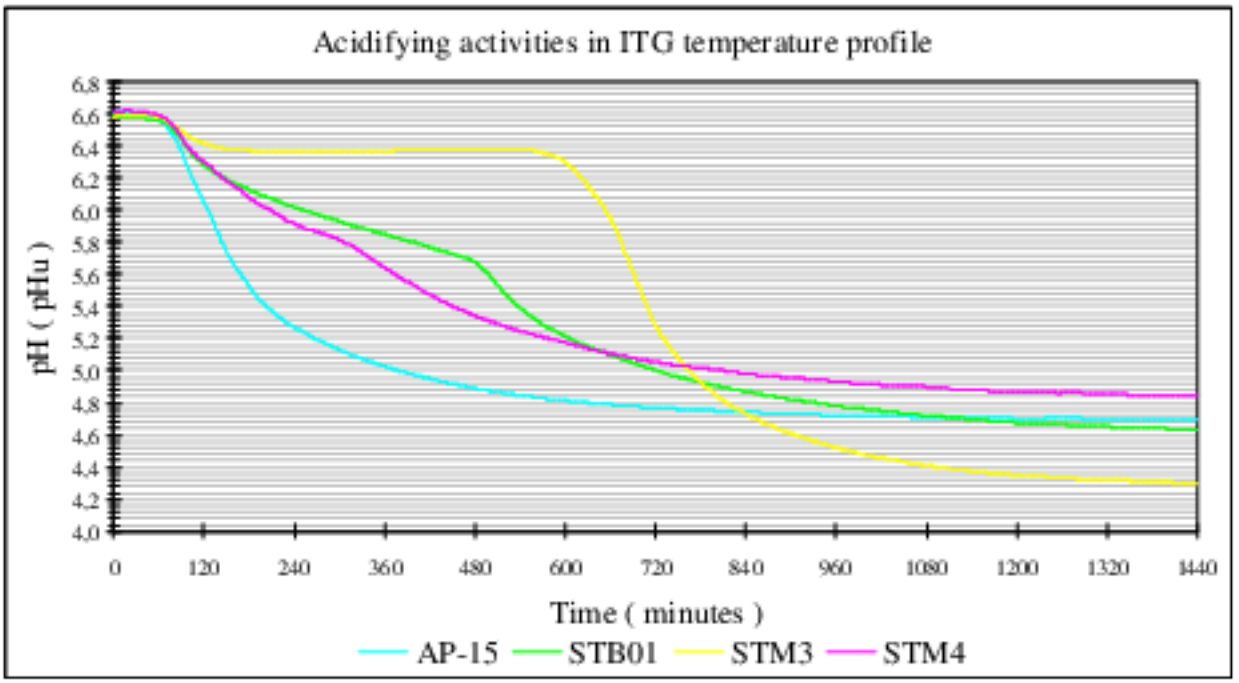
Concentration unity : mg/g.

Determination of racemic lactate production by HPLC

	LH-32 - 40°C (104°F)	LHB-01 - 40°C (104°F)	LHB-02 - 40°C (104°F)
D-lactic acid	1.6	5.9	5.7
L-lactic acid	9.5	12.2	11.6
Total lactic acid	11.1	18.1	17.3

Concentration unity : g/l

5.2 Technical information on *Streptococcus thermophilus*



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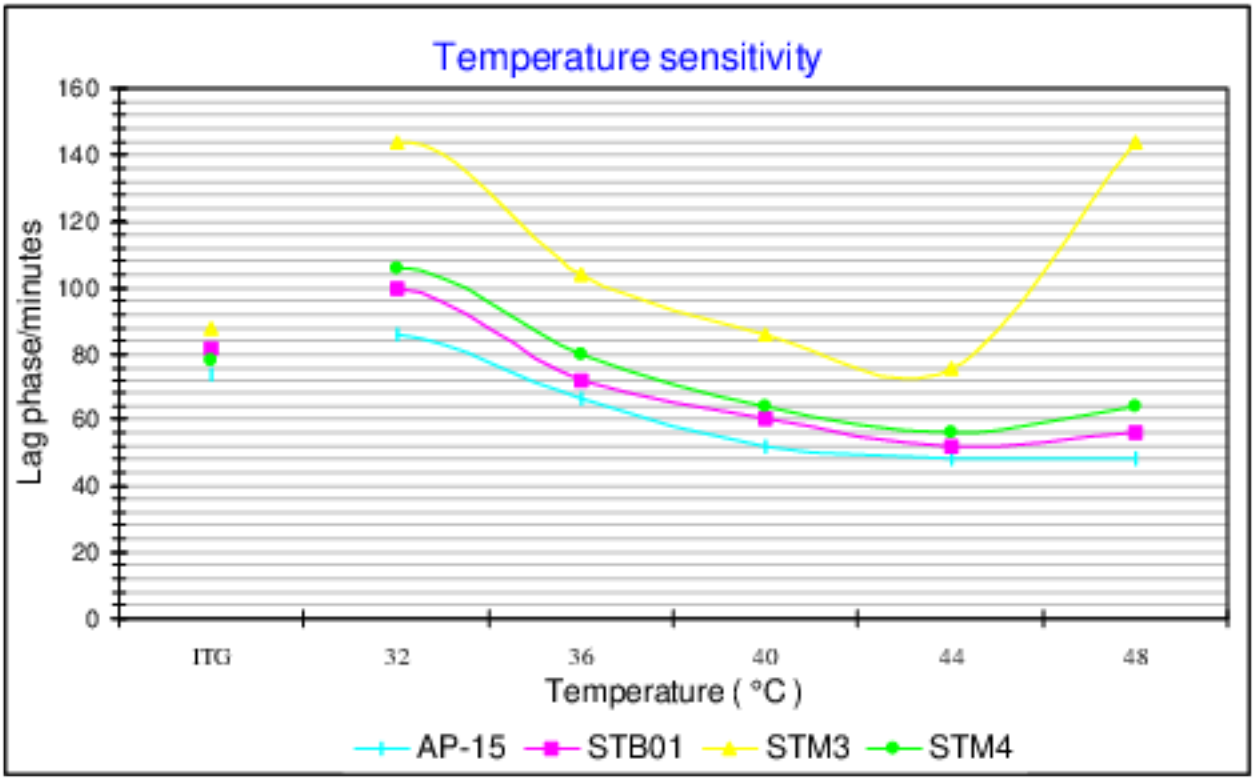

Acid and sugar contents in fermented milk by HPLC

	AP-15 - ITG	STB-01 - ITG	STM-3 - ITG	STM-4 - ITG
Citric acid	2	2	2.2	2.1
Lactic acid	4.9	5.2	6.1	5.1
Acetic acid	0.4	0	0	0
Lactose	36.8	35.9	35	38.2
Galactose	4.9	5.9	7.1	4.9

Concentration units : mg/g.

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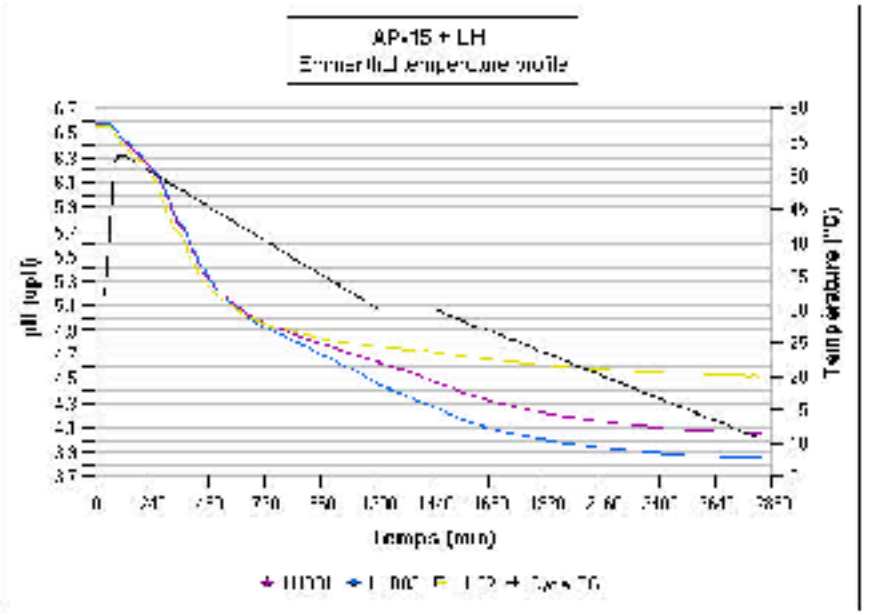
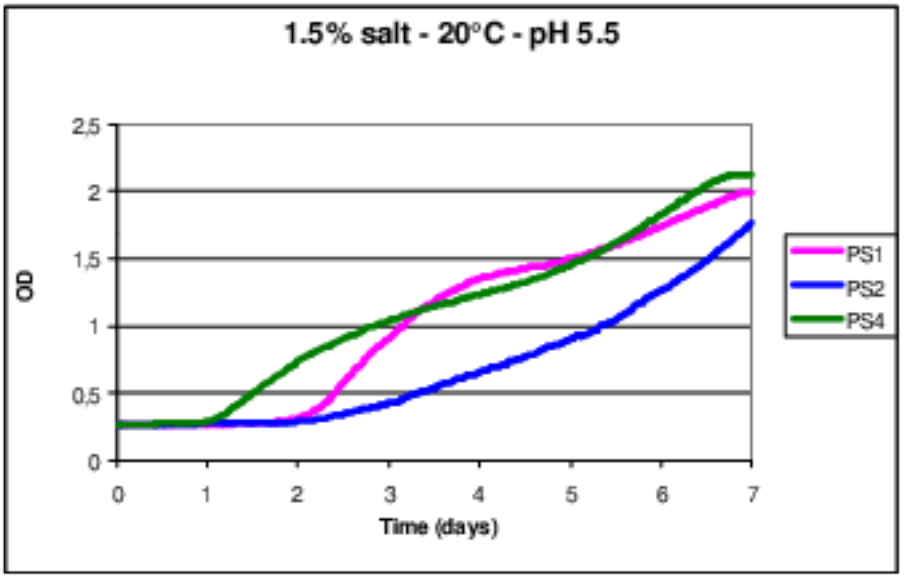


5.3 Technical information on Propionic Acid bacteria



Synthesis (optimal growth conditions)

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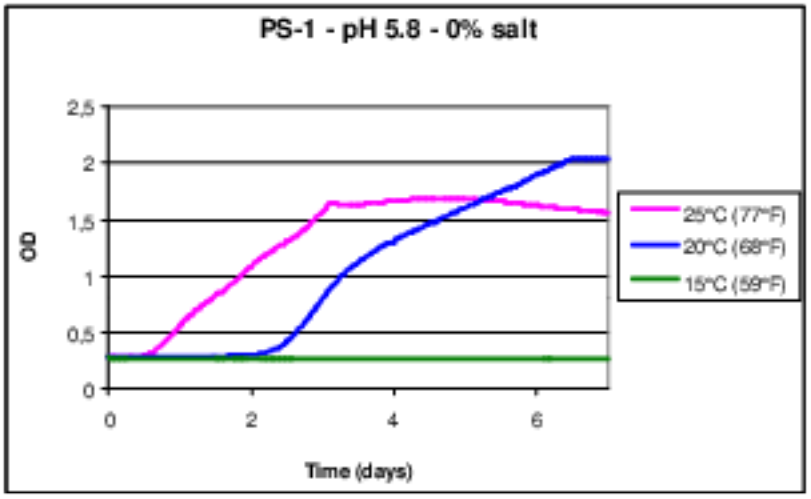

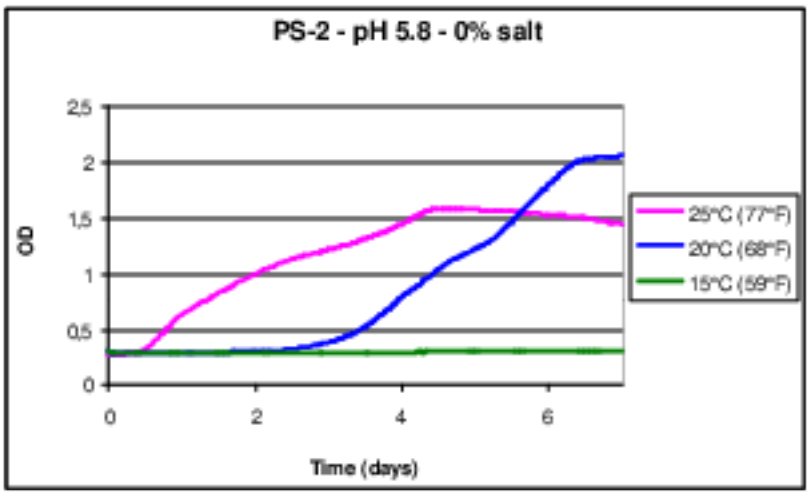

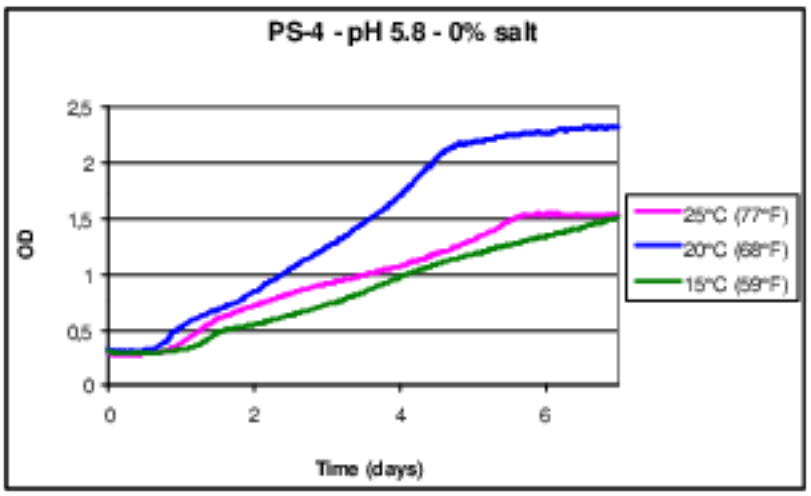

Temperature effect

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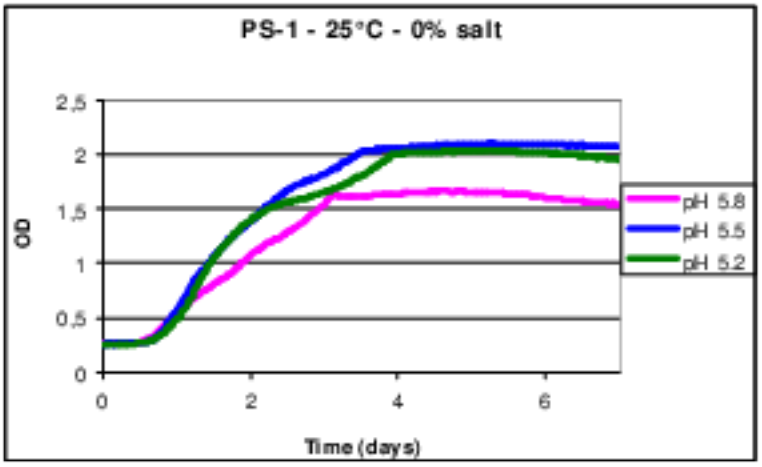

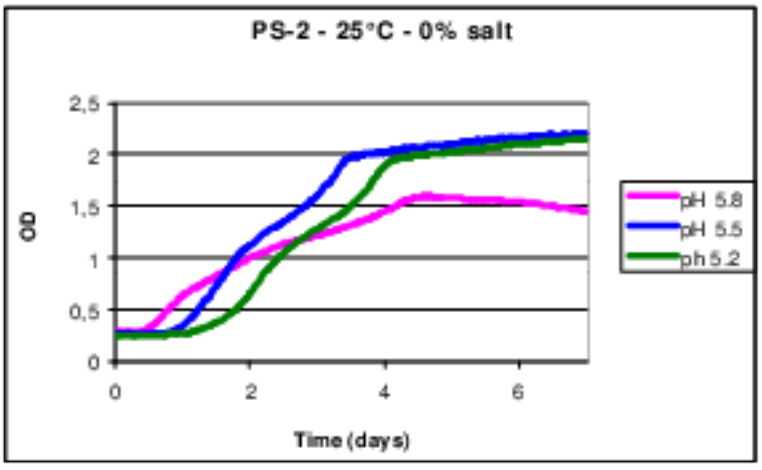

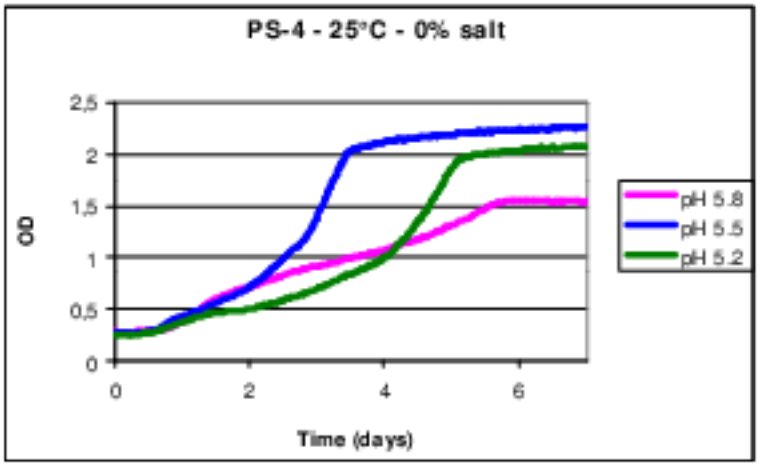

pH effect

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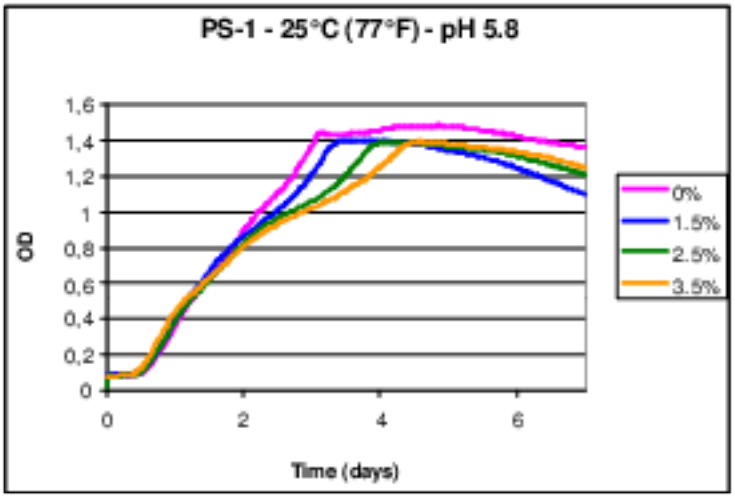

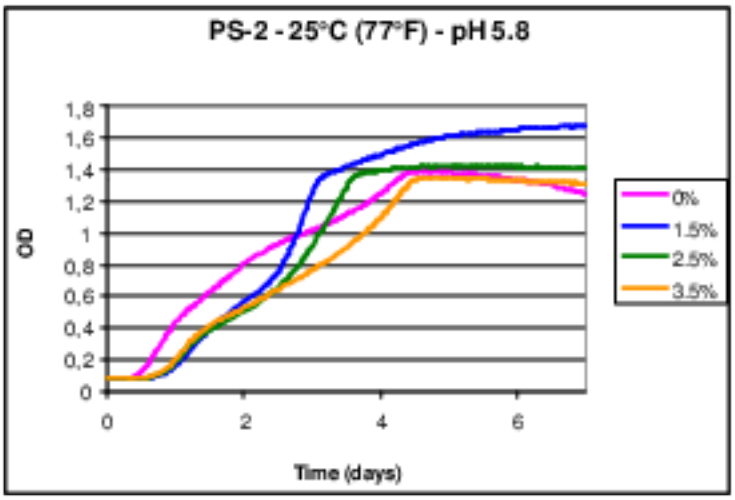

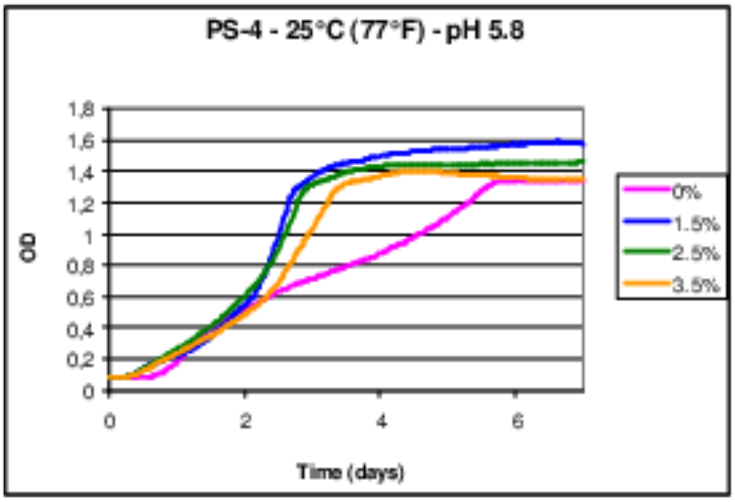

Salt rate effect

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Symbiosis between LH and PS

Boosting effect of LH on PS

Reference: Report ITG [illegible]

	LHB01	LHB02	LH32
PS1	[illegible]	[illegible]	[illegible]
PS2	+++	++	+++
PS4	+++	++	+++

Gas Production by PS

Reference: Report ITG [illegible]

PS1	++
PS2	[illegible]
PS4	+++

Effect of lysozyme on LH acidification

AF ACT (20% lysozyme) [illegible]

LHB01	LHB02	LH32
No inhibition	slowing down	No inhibition

Residual carbohydrates in cheese after 20 hours

Measured on curd (HPLC)

from experimental results

	LHB01	LHB02	LH32
Lactose	very low	very low	very low
Galactose	low	none (or trace)	none (or trace)

Proteolysis on cheese after 60 days

from experimental results

	LHB01	LHB02	LH32
NS/N	moderate	very high	high
NPN/N	moderate	very high	high

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6. Cause and prevention of faults in Emmenthal cheese types

Most of the Emmenthal cheese problems deal with eyes and the appearance of the curd at cutting.

Eye formation
As has already been seen, numerous factors contribute to eye formation, making the process complex.

Problems with eye development can be divided into two groups:

- Unfavorable conditions for PAB growth (see section 4) result in number and distribution problems.
- Imbalance of all the parameters (PAB activity, proteolysis, plasticity of the curd...see section 3.2.8) involved in eye formation. Curd moisture for, example, gives shape and size faults.

Examples:
Due to the large size of Emmenthal cheeses, when processing difficulties (such as acidification, pressing, acidification, room temperature) occur, there can be localized variations in the cheese. For example in a cheese that is dry, acid and salty on the outside and the center is moist and low in salt, eye formation will be concentrated in the center, the outside remaining blind. (See section 4, PAB's pH and salt sensitivity).

Shape problems
- Low moisture: problem with "scratched" eyes.
- High moisture: problem with orange skin or nutshell.
- PAB activity too high: collapsed eyes.

Appearance
- Slits: the result of the production of CO_2 in a curd lacking elasticity.
- "Acid slits" or "fat slits": may be the result of using acid milk (infrequent nowadays) or processing difficulties (lack of drainage) giving too high acidification and emineralization of the curd with loss of elasticity.
- Using milk that is too fatty may lead to the same problems (if drainage is not sufficient).

- Late slits

May occur with late PAB fermentation resulting in weak elasticity due to:
  - Proteolysis being too advanced
  - Cold curd in storage room (in this case with PAB still working at low temperature).

Case of *clostridium butyricum* "late blowing".
Clostridia are spore forming and ferment lactate to release butyric acid, CO_2 and H_2.

Hydrogen gas may cause eye defects ("cauliflower eye"), split, or cheese blowing.
Clostridia are pH sensitive and grow best anaerobically in the later stages of ripening, when the pH is higher.
Clostridia smell is accompanied by the smell of butyric acid and a rancid taste.
The use of bactofugation and lysozyme reduce the growth of clostridia.

In general the following points are essential for a good start in Emmenthal type cheese production:

- Use milk with low cell count.
- Ensure the correct balance between the starter cultures (ST, LH).
- Maintain the "rennet" character of the cheese process.
- Maintain minimum processing times to consume all the sugars in the curd before brining.

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