SPECIALTY CHEESE CULTURE SELECTION

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Summary

Cheese culture selection is an important part of the cheese production process. Culture requirements vary depending on the type of cheese produced. Other factors that can affect this determination are the style of cheese, equipment used to process the cheese, and even packaging. While commercial culture varieties are comprised primarily of Lactococcuss and Streptococcus bacteria, other strains are also used. This discussion will involve culture selection, culture propagation, cultures and their effect on the cheese making process, as well as cultures and cheese ripening, and causes of slow starters.

In determining what type of culture should be used to produce a cheese, several factors should be considered. Among these would be temperature and tolerance: where the strains perform best, and what temperature is the maximum or minimum that they can withstand. If openings are required for gas production, for example, the necessary culture should be used. The culture must perform within the constraints of salt usage, and the effects of proteolysis and lypolysis considered.

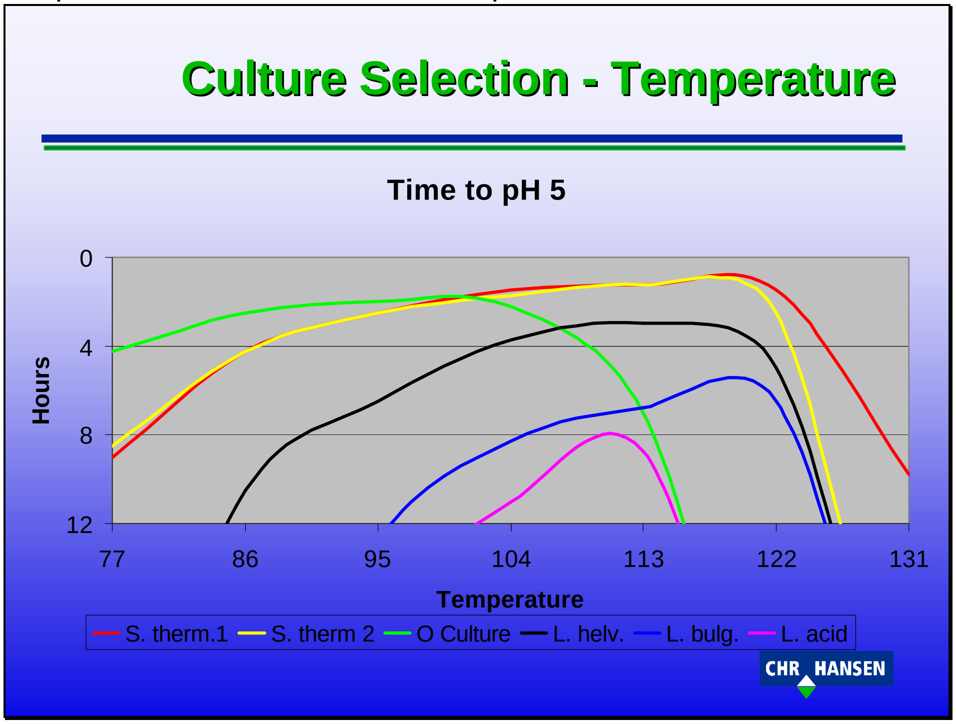
Discussion

The primary function of a bacterial culture is to provide acid development through the fermentation process. This pathway is for lactose to be converted to glucose or galactose, and from these sugars then converted to the end product of lactic acid. In the discussion of culture selection, a grouping of cultures can be made by basic temperature requirements. These groups are called mesophilic or thermophilic with the temperature requirements for the thermophilic generally higher than mesophilic.

Each of these cultures run at different temperatures. In the case of L. acidophilus and L. bulgaricus, real growth doesn't begin until the temperature is above 95F. L. helveticus begins to show more growth at a lower temperature, while "O" type or mesophilic cultures have a flatter growth curve beginning around 77F. It is interesting to note that specific strains of culture can have slightly different growth curves. In the instance of S. thermophilus 1 vs. S. thermophilus 2, number one appears to do slightly better at a warmer temperature. Therefore, when selecting cultures for a specific type of cheese, factors such as equipment, packaging size and final product size; as well as temperature and growth curves of the specific strain of culture can also have an impact.

The taxonomy, or classification of cultures is determined by differentiation between various strains of bacteria based on several criteria. These differences help classify strains based on their specific characteristics and aid in the selection of cultures for specific cheese makes.

Graphic 1—Culture Selection-Temperature



In looking at various types of cheese that can be produced, several cultures are primarily used. In the case of “dry salt” cheeses such as Cheddar, Colby, or Monterey Jack, “O” type cultures are utilized. These cultures are made up of combinations of Lactococcus lactis ssp.lactis and Lactococcus lactis ssp. cremoris. The primary end product of fermentation with these strains is lactic acid. In producing cheese varieties such as Blue, Cream or Baby Swiss, a different selection of cultures is required. These cultures are of the “D” classification. Lactococcus Lactis ssp. lactis biovar.diacetylactis is the organism used, and the end products of this fermentation are lactic acid, diacetyl, and carbon dioxide. The diacetyl flavor compound is what provides the “buttery” note associated with these cheeses, while carbon dioxide provides some of the openings. Another type of mesophilic culture is the “L” type, which is comprised of Leuconostoc mesenteroides ssp. cremoris. This culture is used in the production of cream cheese, as well as other continental cheeses, and its end products include diacetyl, ethanol, and carbon dioxide, though generally not as much CO2 as is produced with Lactococcus lactis ssp. lactis biovar.diacetylactis.

Another difference is in what food sources the bacteria can utilize, such as lactose or citrate, as well as the previously mentioned temperature requirements.

Graphic 2.—Culture types: Mesophilic

CULTURE TYPES: Mesophilic

Taxonomy:	Produces:	Used In:
• *Lactococcus lactis* ssp. *lactis* • *Lactococcus lactis* ssp. *cremoris* • " O Culture"	▪ Lactic Acid	❖ Cottage Cheese ❖ Cheddar, Colby Jack ❖ Others
• *Lactococcus lactis* ssp. *lactis* biovar. *diacetylactis* • " D Culture"	▪ Lactic Acid ▪ Diacetyl ▪ Carbon Dioxide	❖ Blue Cheese ❖ Cream Cheese ❖ Baby Swiss
• *Leuconostoc mesenteroides* ssp. *cremoris* • " L Culture"	▪ Diacetyl ▪ Carbon Dioxide	❖ Cream Cheese ❖ Continental Varieties

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Graphic 3--Mesophilic Cultures

Mesophilic Cultures

	Lactococcus lactis/cremoris	*Lactococcus diacetylactis*	*Leuconostoc*
Ferment Lactose	Acid	Acid	Acid & CO_2
Ferments Citrate	Acid	Acid, CO_2, Diacetyl	Acid, CO_2, Diacetyl, Ethanol
Optimum Growth Temp.	88 – 92º F	88 – 92º F	74º F
Maximum Growth Temp.	104º F – L crem. 113º F – L lactis	113º F	88º F

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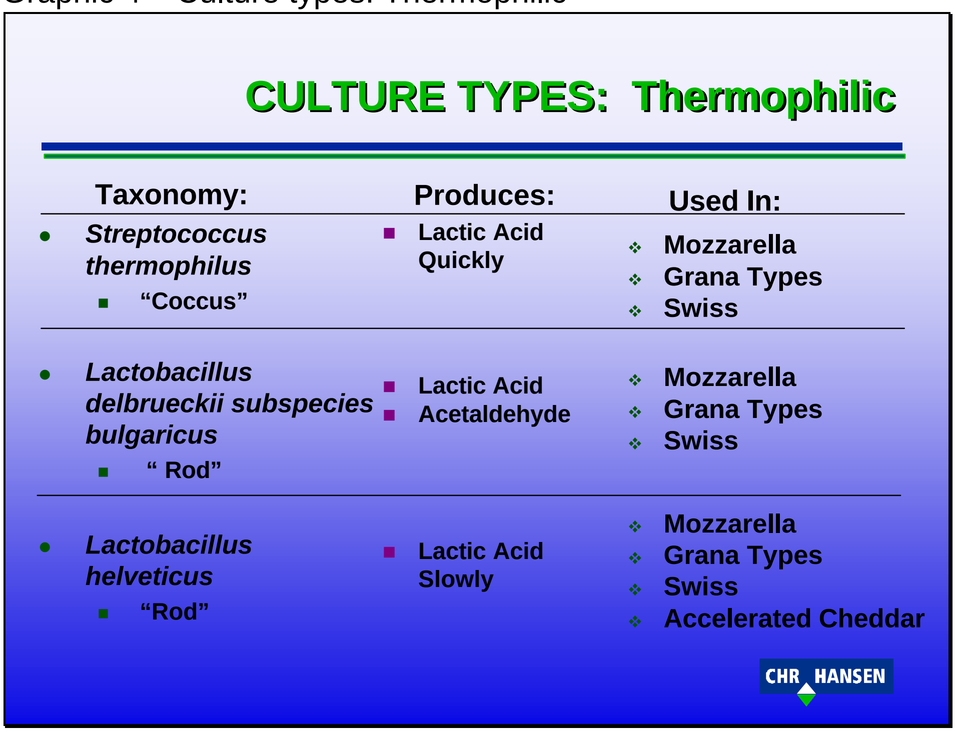
In selecting cultures for mesophilic cheese type production, food sources as well as temperature are factors. While the previous graphic shows some growth at higher temperatures, the typical maximum temp for L. cremoris is 104 and L. lactis 113, with the general maximum temperature for L. diacetylactis and leuconostoc 113 and 88 respectively.

On the thermophilic side, the taxonomy also subdivides by the differentiation of bacteria shape, either coccus or rod. Streptococcus thermophilus is commonly referred to as "coccus", while Lactobacillus delbrueckii subspecies bulgaricus, and Lactobacillus helveticus are often called "rods". This is in reference to the circular shape of the thermophilus, as opposed to the elongated or rod shape of bulgaricus and helveticus. A characteristic of thermophilus is the rapid production of lactic acid, and it is used in cheese types such as mozzarella, grana varieties, and Swiss. Lactobacillus delbrueckii subspecies bulgaricus has lactic acid and acetaldehyde as its primary end products. It is similar to thermophilus type cultures in that it is also used in the production of the same types of cheeses. In fact, these can be used independently or in combination, again depending on the type and desired characteristics of the finished cheese.

Graphic 4 – Culture types: Thermophilic



These cultures can also be defined by their fermentation food source, in this case lactose or galactose as well as temperature requirements. One differentiation is the ability of these cultures to ferment galactose, which can be a factor in producing cheese that is darker or "browner" than customer requirements dictate. Optimum growth ranges are similar but not identical.

As discussed earlier, various bacteria are classified into groups based on food source, temperature requirements, physical shape, and fermentation end products. Another criterion is salt, which performs many functions. Salt can slow the growth of bacteria, release water from the curd, condition the curd for pressing, enhance flavor, and discourage the growth of pathogenic and spoilage bacteria. However, identity standards and customer criteria will have an effect on the amount of salt used. In addition, the culture bacteria are affected at different rates by salt. For example, while Lactococcus can have its growth affected by 50% at salt levels of 5% (salt in moisture); salt levels of only .8 % similarly affect L. bulgaricus.

Graphic 5—Thermophilic cultures

Thermophilic Cultures

	Streptococcus thermophilus	*Lactobacillus bulgaricus*	*Lactobacillus helveticus*
Ferment Lactose	**Acid & Galactose**	**Acid & Galactose**	**Acid**
Ferment Galactose	**Mostly No**	**No**	**Yes**
Optimum Growth Temp.	**106 - 110º F**	**110 - 115º F**	**110 - 115º F**
Maximum Growth Temp.	**132º F**	**125º F**	**125º F**

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Graphic 6 – Salt Tolerance

Salt Tolerance

Culture Type	50 % Inhibition	100 % Inhibition
Lactococcus	**5.0 - 5.5 %**	**> 6.0 %**
S. thermophilus	**1.7 – 2.5 %**	**> 3.0 %**
L. bulgaricus	**0.8 – 2.1 %**	**2.0 – 3.0 %**
L. helveticus	**3.1 – 4.0 %**	**4.0 – 5.0 %**

All % as Salt – In - Moisture

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In addition to mesophilic and thermophilic cultures, other strains are used to provide cultures for specialty cheese types. For example, in the production of Swiss cheese, propionibacteria is used to produce the eyes and flavor associated with this cheese. Penicillium roqueforti is used to create cheeses such as Blue and Gorgonzola, while Brevibacteria is a culture used for the production of Limburger, Muenster, and Brick. Other cultures that can be used in the modification of flavor, or for use in other specific cheeses are Lactobacillus casei and other differentiated strains.

Graphic 7—Culture Types: Flavor and Ripening

CULTURE TYPES: Flavor and Ripening

Culture	Cheese Type
Propionibacteria	**Swiss**
Penicillium roqueforti	**Blue, Gorgonzola**
Brevibacteria	**Limburger, Brick, Muenster**
Lactobacillus casei	**Accelerated Ripening & / or Flavor Modification**
Modified Strains	

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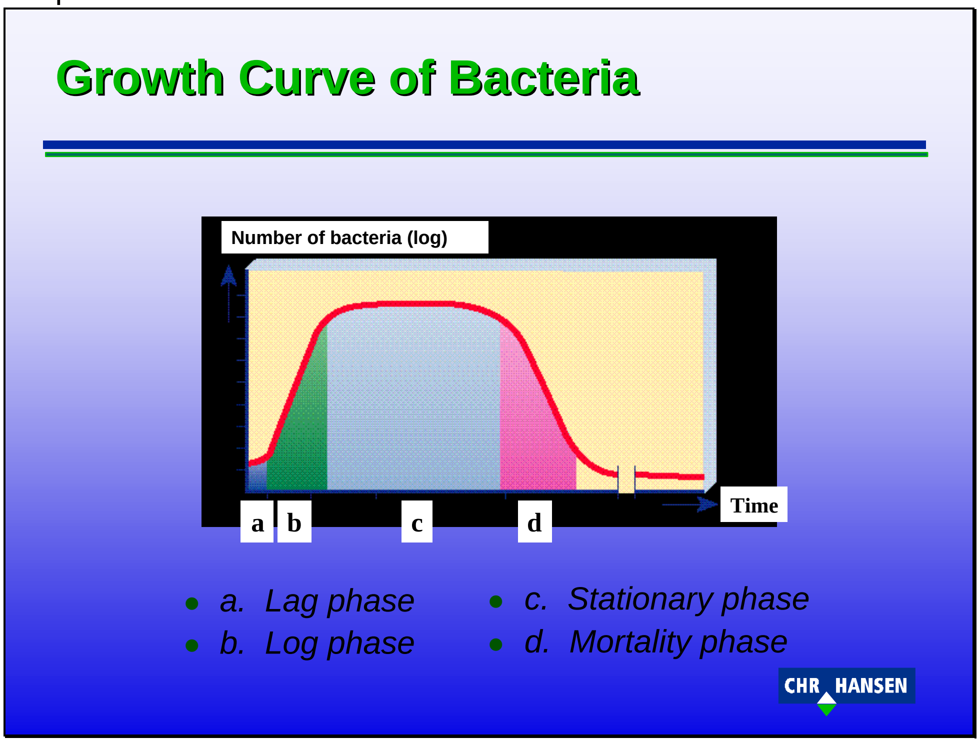
Some of these cultures can be used by themselves, but they are primarily used along with an acidifying culture to refine or develop a specific flavor. An economic consideration is the length of time required for storage of aged cheeses. The fact that specific cultures can accelerate flavor development can help reduce the time requirement of the aging process.

Cheese culture, or starter culture, has been developed and modified through the years. Originally, natural starter was used in the cheese production process. In order to obtain repeatability, when a good culture was obtained, steps were taken to insure that the starter was maintained. This could be done by adding back inoculated cheese milk or whey, or by maintaining a mother culture for repeated use. To standardize cheese production further, commercial cultures were developed either in the form of bulk starter culture or Direct Vat Culture.

The type of bacterial strains present can then refine these two styles of culture. In undefined, mixed multiple strains, there is a mix of known species, but unknown number of strains. In defined, mixed multiple strains, there is a mix of known species and strains. And in single strain cultures, there is a single strain of a known species. Commercial forms of culture can be frozen liquid (can), frozen pellets, or freeze-dried powder.

The growth of bacteria can be defined in four steps: the lag phase, log phase, stationary phase, and mortality phase.

Graphic 8—Growth Curve of Bacteria



The type and environment of the starter culture will affect these phases. For example, a DVS culture will not initially acidify as quickly as bulk culture, and external ph control can assist the bacteria by keeping them in the stationary phase longer by maintaining a proper Ph. Ways to monitor the condition of a bulk culture include activity test, phage testing, and microscopic evaluation and by cell count.

Starter and the cheese process have a symbiotic relationship. Conditions in the vat affect the starter, and likewise the starter affects the finished cheese product. Amounts of starter vary by cheese variety, starter type, and the desired make time. Ripening times can vary from 30 to 75 minutes for Frozen Concentrated culture, to 10 to 30 minutes for ph controlled bulk starter. Ripening increases the level of desirable bacteria, starts acidification/lowers Ph, and controls the rate of acid production. The cooking step in cheesemaking stimulates thermophilic bacteria, and slows mesophilic growth and acidification. Washing the curd will also control acidification by affecting temperature and removing lactose. The salting step, among many functions, slows bacterial activity, though strain specific. (Graphic 6) The salted curd can then be placed in hoops, pressed/packaged while the bacteria continue to lyse and release peptidases into the cheese.

A number of cultures can be used for creating specific flavors in cheese. These cultures are often used with an acidifying culture.

Graphic 9—Cheese Ripening Cultures

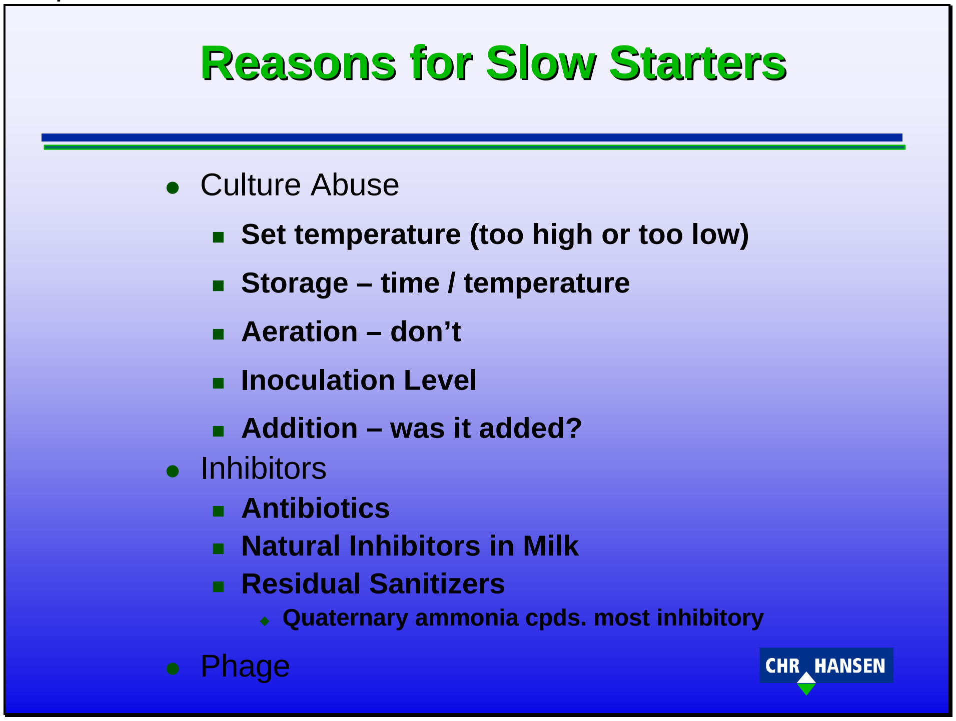
Portfolio of Cheese Ripening Cultures

Segment	Ripening culture	Microorga-nisms in the culture	Cheese segments suited for the cultures	Main effect
Flavor Control™ Range	CR	*Lactococcus*	Continental Grana Emmenthal Cheddar	- Enhance flavor note - Debittering - Farmhouse flavor - Accelerated ripening
	LH	*L. helveticus*		- Enhance cheese flavor - Contribute sweet, nutty, meat like flavor - Debittering
	Emfour	*L. helveticus* + *L. acidophilus*		- Enhance cheese flavor - Contribute sweet, nutty-like flavor - Debittering
	PS	*Propioni-bacterium*		-Sweet, nutty flavor, CO_2 production
SWING™		Yeast PC, PR , Geo*) Brevi-bacterium Staphylococcus	Soft cheeses Continental cheeses	- Enhance cheese flavor in surface ripened cheese - Enhance farmhouse flavor in interior ripened cheese

A ripening culture made up of lactococcus has various functions, including debittering, accelerating the ripening process, and enhancing flavor notes. The use of L. helveticus also contributes to debittering, enhancing cheese flavor, and contributing a sweet, nutty flavor. A combination of L. helveticus and L. acidophilus can be used to obtain the similar flavoring characteristics. In addition, other types of culture can be used to accelerate flavor production by enhancing cheese and farmhouse flavors.

When selecting the best culture for an application, situations can arise where the culture does not perform satisfactorily. For example, set temperature that is too high or low (outside of the cultures optimum range) will affect performance. The culture can also be affected by storage. If the culture is held outside its maximum storage time, or if the temperature of the freezer warms, cell damage can occur. Cultures for cheese production are primarily comprised of facultative anaerobes, and thus are influenced by excess agitation or air incorporation. Cultures can also be impacted by the presence of residual sanitizers, natural inhibitors, and antibiotics. Bacteriophage is also a major consideration in culture selection and performance.

Graphic 10—Reasons for Slow Starter



One of the most common issues, especially in summer months, is the care and storage of the culture after shipment arrival. Frozen culture, that is warmed before being put away at a proper storage temperature, can sustain cell damage and affect acidification. If inhibitors have been ruled out as a source of slow growth, bacteriophage contamination may be the problem. Bacteriophage or phage means "eaters of bacteria", and are viruses that attack or lyse bacterial cells. They are the main cause of starter culture failure, and can only be controlled, as they cannot be eliminated from the environment. They can survive normal pasteurization, and have the ability to remain dormant but viable for years.

Phage can be tested or monitored through laboratory techniques that include an inhibition test or plating. Controlling phage can be accomplished by operational design, sanitation, and culture selection. Cheese vat rooms should be kept dry and maintain proper airflow. Whey/product on the floor should be minimized, and drains should be properly cleaned and sanitized. All product surfaces should also be properly cleaned and sanitized, using sanitizers such as chlorine that kill phage. Proper culture rotation assists in phage control, as well as direct inoculation methods which reduce in-plant contact time. A factor in any cheese culture selection is that some cultures are more phage resistant than others. In addition, strains can be categorized into groups that are attacked by specific phage

Conclusion

While cheese type is a primary consideration for culture selection, other factors can have an effect on what type of culture is used. Different types of cultures are available, as well as alternate styles of culture packages. Cultures are affected by conditions such as temperature or salt, and can be used to modify or accelerate flavor production. They must be given the proper food source and growth conditions to perform well in the vat and also be protected from bacteriophage. When these factors are considered, cultures can then be selected to help produce cheese of the desired quality and specification.