Introduction

The Corbion Listeria Control Model helps processors to develop Ready-to-Eat meat products and refrigerated foods, by predicting the growth of *Listeria monocytogenes* in specific food matrixes. It has been developed using a data set of over 2500 individual growth curves of statistically-designed experiments and expands upon prior models that have been used successfully for many years by both large and small meat/food companies.

The applicability of a predictive growth model depends on the amount of environmental parameters taken into account. The Corbion Listeria Control Model enables you to model growth according to eight food parameters; storage temperature, moisture content, pH, Sodium Chloride, Potassium Chloride, Sodium Nitrite, water activity and Corbion product. The levels of these parameters are based on total product formulation.

Appropriate use of the model increases the relevance of challenge studies and can aid in their design. We advise you to apply the guidelines in this document when using this model. If you have any questions or remarks, feel free to contact Corbion via your local representative or www.corbion.com/contact. Our experts are eager to help you.

About the model results

For a specific set of food characteristics Listeria challenge studies show variation at each point in time. Variation in Listeria growth is caused by study specific and processor specific situations, such as difference in Listeria strains, general production variation and different pre-cultivation methods. This variation can be represented by a normal distribution (Figure 1).

The Corbion Listeria Control Model uses the variation of the data set to show a graph with four growth lines - two red lines for the control and two blue lines for the situation after addition of a Corbion product. A grey area surrounds the blue line (Figure 2) visually representing the normal distribution of Listeria growth variability. The solid growth curves represent the so-called ‘best fit’ lines, while the dotted lines are the corresponding 95% lines. The best-fit line, 95% line and the grey area enables a direct comparison between the model’s data set and individual Listeria challenge tests.

![Variation in Listeria growth at a specific point in time](image)

**Figure 1**
Descriptive image of a normal distribution curve representing variation in Listeria growth. The distribution curve correlates with specific food characteristics observed at a specific point in time.
The Corbion Listeria Control Model generates the ‘best-fit’ line by connecting the most probable Listeria counts for every point in time. The best-fit line therefore represents the most probable Listeria growth for the specific food characteristics entered into the model (figure 1).

According to the data set, 95% of the growth is expected to be slower than the 95% line. If the model’s data represent your situation, you should expect that in 95% of the cases where Listeria is present, growth occurs on the dotted line, or later.

The grey shading which surrounds the best fit line represents 95% of the distribution within the bell shaped curve in Figure 1. It is darkest near the best fit line and lightens as it moves further from the line. The grey area above this best fit line indicates growth more rapidly than the best fit line. Grey shading below the best fit line indicates slower growth than the best fit line. Chances of Listeria growth occurring outside the grey area are minimal.

Figure 2
Example of Listeria growth graph as shown by the Corbion Listeria Control Model.

During the process of food product development, safety margins should be incorporated into the product shelf life. The exact size of the margins depends on:

- Company policy regarding shelf life and safety
- Variations between batches of food products
- Your Listeria challenge studies
- Local regulations and policy

Company policy regarding shelf life and safety should be determined prior to usage of this model. This includes a corporate guideline of shelf life definition related to safety testing of a product. We advise to include these best practices guidelines into the company policy.

Local regulations and policy should be known prior to product development, and can be used to set a target shelf life and product formulation.
Variations between batches of food products

By taking into account variations between food product batches, ‘worst case scenarios’ can be simulated wherein Listeria growth is highest. The guidelines below describe how to calculate variations and how these should be entered into the model.

Table 1 can be used to simulate minimal inhibition of Listeria growth within the variation of a food product.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Enter Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth vs. no growth</td>
<td>Consider conditions where no growth (i.e. less than 0.5 log) occurs during the product shelf life.</td>
</tr>
<tr>
<td>Temperature</td>
<td>Enter highest storage temperature found in the distribution chain.</td>
</tr>
<tr>
<td>Moisture level</td>
<td>avg +2SD</td>
</tr>
<tr>
<td>Sodium nitrite levels</td>
<td>avg -2SD</td>
</tr>
<tr>
<td>pH</td>
<td>avg +2SD</td>
</tr>
<tr>
<td>Salt (NaCl and KCl)</td>
<td>avg -25D</td>
</tr>
<tr>
<td>Corbion product</td>
<td>avg -2SD</td>
</tr>
</tbody>
</table>

An average and standard deviation based on 30 or more different lots of production is desired. A minimum of five to ten values is required to get a representative value of variations.

If no data on variation is available, the cooking yield of a product and the 95% line can function as a measure of variation. The 95% line is a measure of variation of the data set used for the model. This can be held as a substitute when variation in food products are unknown.
Your Listeria Challenge Studies

The Corbion Listeria Control Model is based on a large amount of data, which does not always represent producer specific situations. On the other hand, a producer’s specific Listeria screening data sets are less extensive and do not reveal the full variation of your situation. Therefore a balance must be found between the predictions of the model and producer specific data and experience.

The general rule is to start with the model and benchmark the prediction with data and experience. The benchmark can be used to adjust a product formulation in such a way that a more desirable Listeria growth is predicted. If your challenge data is consistently close to the best-fit line, you can assume the model’s variation is equal to your variation. By using the 95% line, predicted Listeria growth is higher, after all: 95% of growth is expected to be slower than the 95% line. Adjusting the product formulation according to this line, results in a product with a higher safety margin.

The choice of using the 95%, the best-fit line or somewhere in between as a benchmark, should be ideally standardized and made by the processor. The consistency and amount of Listeria screening data are important factors to consider: large data sets with consistent results are a good basis for a solid benchmark.

In some cases processor specific situations, such as a difference in Listeria strains and different pre-cultivation methods, can cause a difference between your data and LCM prediction. If a structural difference is seen between your own Listeria challenge data and the model’s results, the model’s prediction can be adjusted accordingly.

Using the advanced settings in the model, the lag time can be adjusted in three ways.
- Calculate a correction factor
- Set a fixed lag time (in days)
- Use no lag time

For more information on how to apply these factors, please read the user guidelines (available in the model).

Remarks

Listeria control is a continuous effort utilizing sanitation solutions such as SSOP (Sanitation Standard Operating Procedures) and HACCP programs (Hazard Analysis and Critical Control Points). The Corbion Listeria Control Model assists in this effort and can shorten the product development cycle. When applied correctly, Corbion products inhibit Listeria monocytogenes growth, but cannot remediate high levels of contamination. Neither this model, nor the use of Corbion solutions should be used in lieu of good sanitation practices!

Corbion cannot be held responsible for the presented results. Use of the model implies you accept the terms and conditions, as set forth on the website of the model. Please go to our website for the terms of agreement.

For further assistance in applying the model, please contact your local Corbion representative.

Interested in learning more about Corbion? corbion.com/food

Corbion is the global market leader in lactic acid, lactic acid derivatives and lactides, and a leading company in emulsifiers, functional enzyme blends, minerals and vitamins. The company delivers high performance bio-based products made from renewable resources and applied in global markets such as bakery, meat, pharmaceuticals and medical devices, home and personal care, packaging, automotive, coatings and adhesives. Its products have a differentiating functionality in all kinds of consumer products worldwide. In 2015, Corbion generated annual sales of € 918.3 million and had a workforce of 1,673 FTE. Corbion is listed on Euronext Amsterdam. For more information: www.corbion.com

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