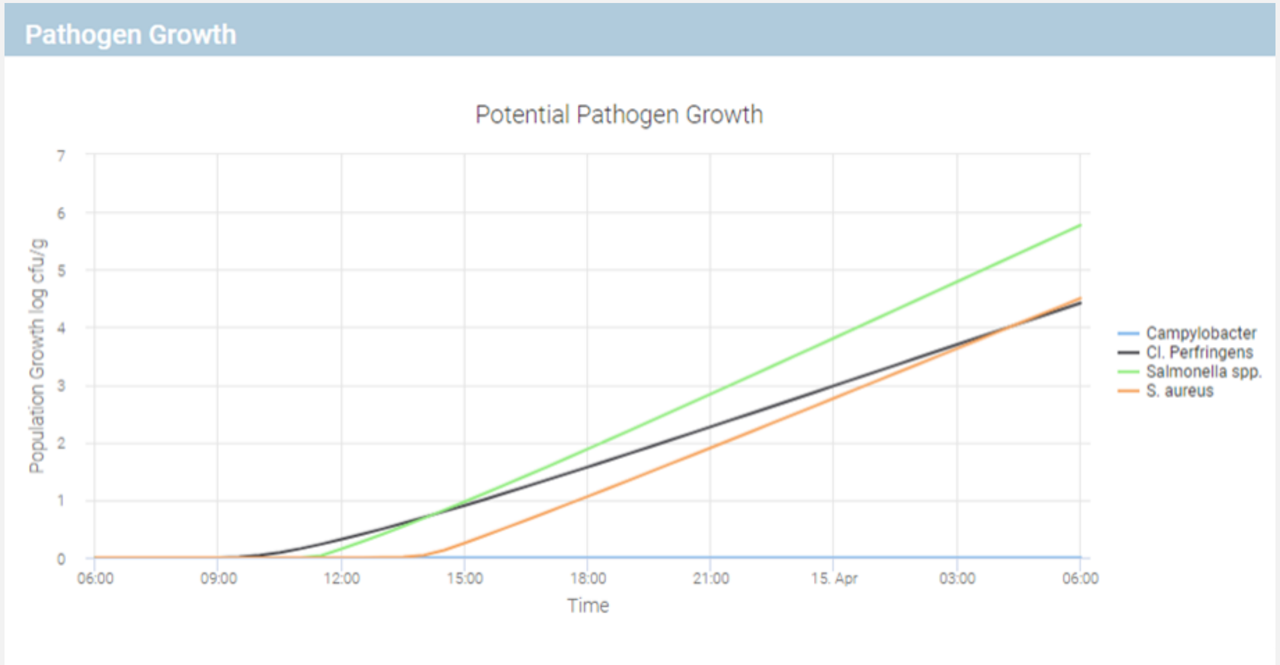
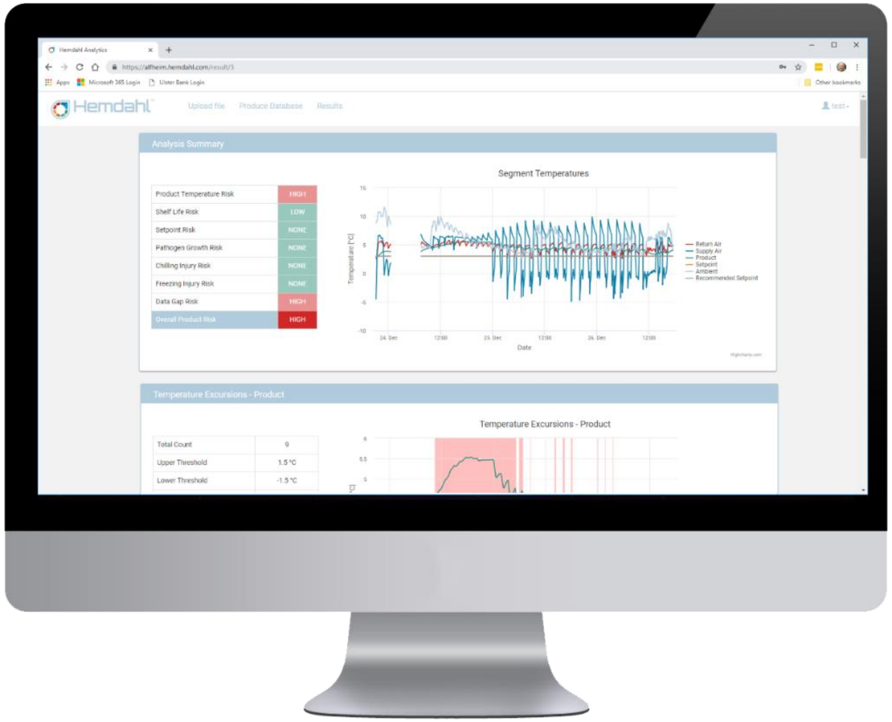
Pathogen Growth Prediction

Ver 1.0



INTRODUCTION

Removing food contaminated with harmful microbiological organisms (pathogens) from the supply chain is not only essential but is also a regulatory requirement. In the EU alone, 5000 people per year die from food-borne illnesses, and hundreds of thousands are hospitalised.
On the other hand, disposing of food that is safe to consume is a huge cause of food waste. Given that 40% of temperature-sensitive food products are discarded, there is a clear need to reduce the amount of food waste in the cold chain.



Accurate prediction of pathogen growth for temperature-sensitive produce is highly desirable, and allows for better decision-making when temperature excursions have occurred in the cold chain.

Pathogen growth prediction can allow us to:

- Remove food from the cold chain that could be harmful to humans and animals.
- Reduce waste by not discarding food that is safe to consume.

In this whitepaper, we consider an approach to develop an accurate model for predicting pathogen growth based on available data such as food group, product temperature, pH, aW, loading patterns, packaging, etc.
This allows for scalable and consistent prediction of pathogen growth at every stage of the cold chain.

PATHOGEN GROWTH MODELS

Food microbiologists have long been developing models of pathogen growth to predict the microbiological effect of storage conditions on food.

Primary Models

There are a number of validated pathogen growth models available, e.g.:

- Baranyi Model
- Gompertz Model
- Logistic Model

Many of these published models work best for isothermal data, and are not suited to modelling the growth of pathogens under varying temperature conditions such as those typically experienced in the cold chain.

Secondary Models

Secondary models (e.g. Ratkowsky model) can be used to predict pathogen growth rates under varying temperature conditions. Combining a secondary model with a suitable primary model results in a tertiary model that can provide useful predictions of pathogen growth rates from real-world data.

$$y(t) = y_0 + \mu_{max} A(t) - \frac{1}{m} \ln\left(1 + \frac{e^{m \mu_{max} A(t)} - 1}{e^{m(y_{max} - y_0)}}\right)$$

Baranyi Model

$$N(t) = C + A^{*} \exp \; -\exp \; -B \; t - M$$

Gompertz Model

$$L(t) = A + \left(\frac{B - A}{1 + e^{(-b(t-m))}}\right)$$

Logistic Model

$$\sqrt{\mu_{max}} = b \; T_K - T_{K\min}$$

Ratkowsky Model

HEMDAHL PATHOGEN MODEL

The Hemdahl pathogen growth model uses a variant of an industry standard 3-phase linear function. This model is widely accepted in the food safety industry as an accurate model for estimating the growth of pathogens on food products.

A secondary model is combined with the primary model to allow for variable temperatures, as experienced in real-world conditions.

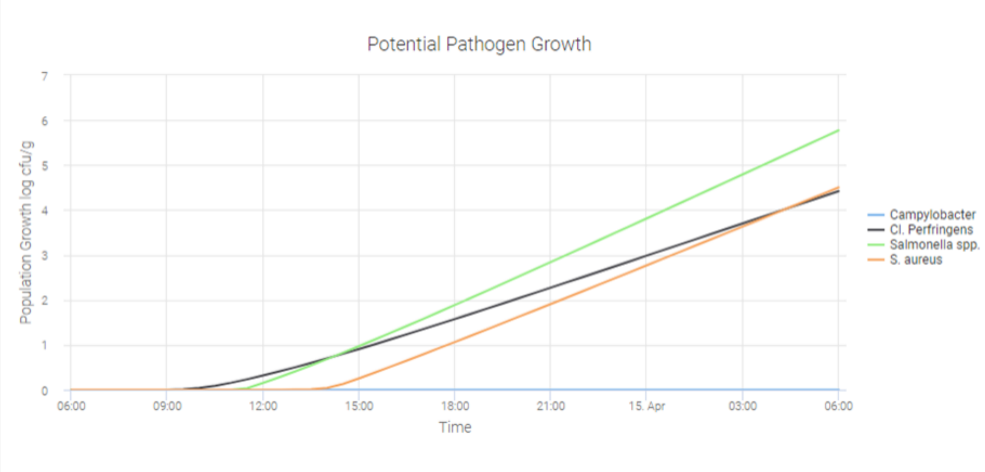
This results in a proprietary tertiary model that can be used to give growth predictions for a variety of pathogens on a wide range of food products in a variable temperature environment.

The Hemdahl pathogen growth model (known as Bifrost) was validated against several well-known pathogen prediction tools.

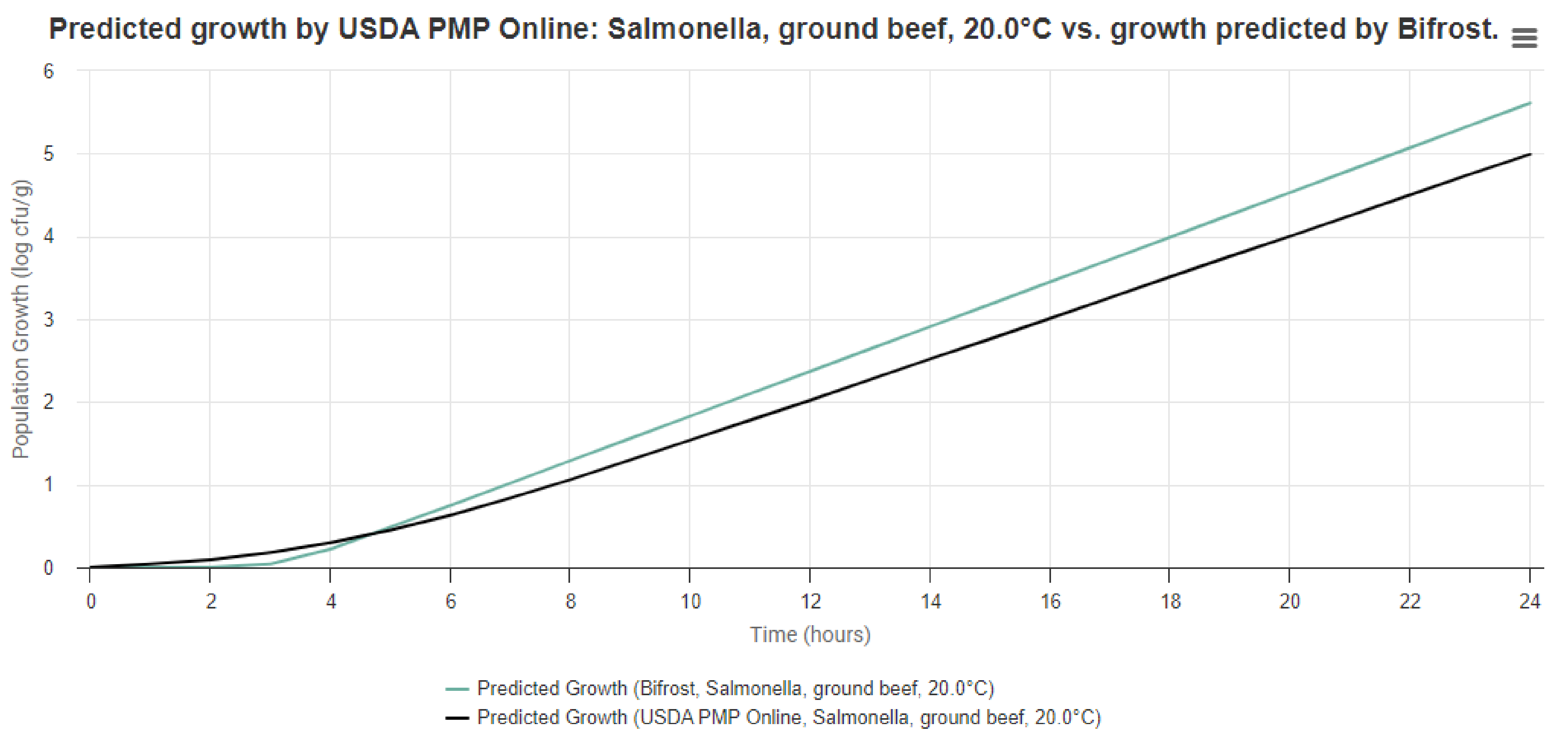
The Hemdahl pathogen growth model was also validated against measured experimental data.

Three examples of Hemdahl model validation are given in the following pages.

Pathogen Growth

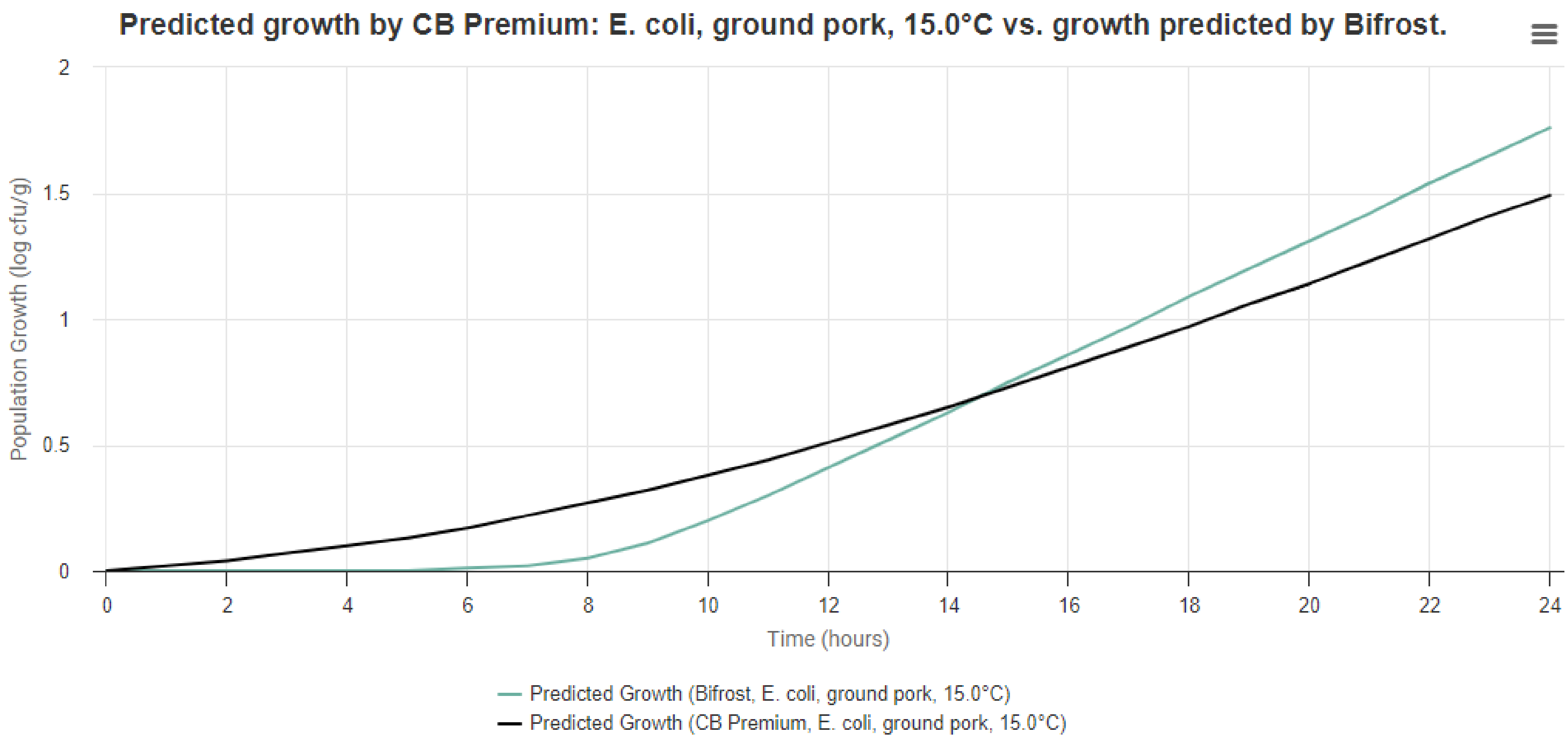


MODEL VALIDATION – USDA PMP TOOL

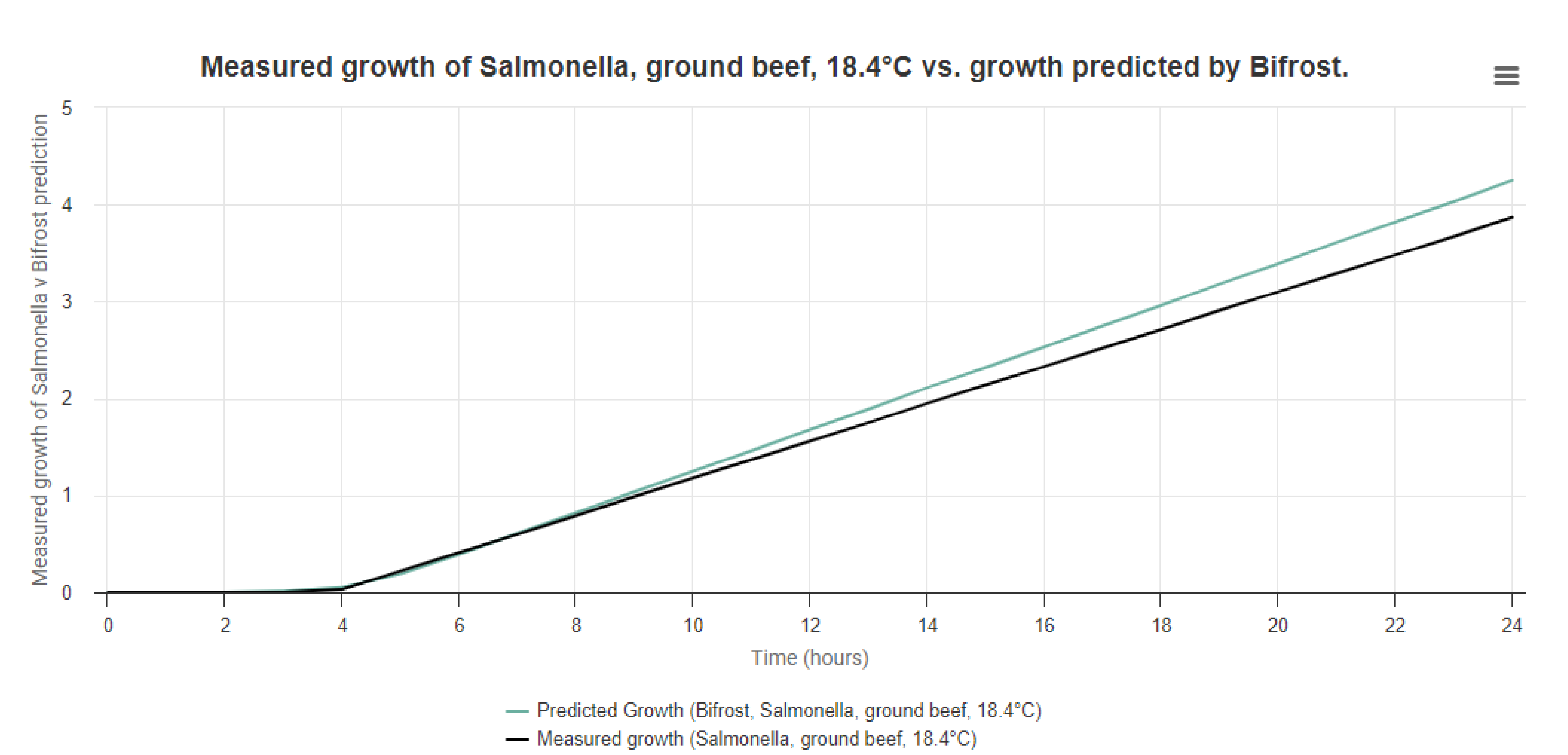


Here we see a comparison between the predicted values of salmonella on ground beef from the Hemdahl pathogen growth model (Bifrost) and the PMP online model from USDA. The Hemdahl pathogen growth model correlates well with the USDA PMP pathogen growth model.

MODEL VALIDATION – CB PREMIUM TOOL



Here we see a comparison between the predicted values of e-coli on ground pork from the Hemdahl pathogen growth model (Bifrost) and the CB Premium pathogen growth model from the Tasmania Institute of Agriculture. The Hemdahl pathogen growth model correlates well with the CB Premium pathogen growth model.



Here we see a comparison between the predicted values of salmonella on ground beef from the Hemdahl pathogen growth model (Bifrost) and measured values from experimental data. Source: "*Predicting Pathogen Growth during Short-Term Temperature Abuse of Raw Pork, Beef, and Poultry Products TABLE 4. Ground beef: observed lag-phase duration (LPD), growth rate (GR), and R2 values.*"

The Hemdahl pathogen growth model correlates extremely well with the actual measured pathogen growth data.

PATHOGEN LIMITS

The acceptable limits for pathogens vary by food group, pathogen type and geographic region. A selection of current limits is given below.

Selected EU Limits

Salmonella spp.: no detectable amount permitted.

Campylobacter spp.: <3 log cfu/g.

Listeria Monocytogenes: < 2 log cfu/g

E. Coli: 5 samples < 2.7 log cfu/g and 3 samples < 1.7 log cfu/g
Ref: Microbiological Criteria Regulation 2073/2005.

Selected US Limits

Salmonella spp.: 1 cfu/g

Campylobacter spp.: detectable in less than 10.4% of samples

Listeria Monocytogenes: < 2 log cfu/g

E. Coli: Beef: < 2.7 log cfu/g

Ref: USDA, FDA.

Selected AUS/NZ Limits

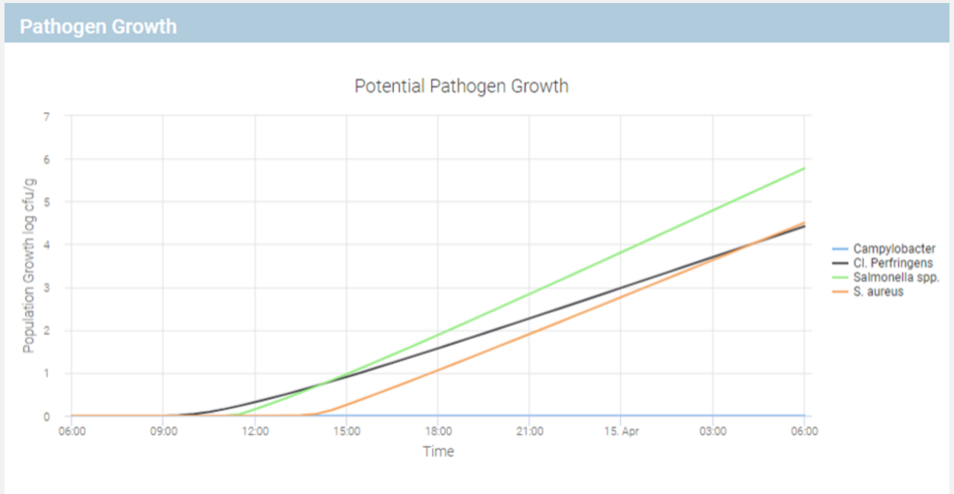
Salmonella spp.: no detectable amount permitted.

Campylobacter spp.: no detectable amount permitted.

Listeria Monocytogenes: < 2 log cfu/g

E. Coli: < 2.7 log cfu/g

Ref: Food Standards AUS/NZ 2016.



CONCLUSIONS

A model to predict pathogen growth over a varying temperature range has been developed. The model includes variables such as produce temperature, pH, and aW, to create accurate growth rate predictions for a wide variety of temperature-sensitive produce. The Hemdahl model correlates well with existing published models such as CB Premium and USDA PMP.
The Hemdahl model also correlates well with measured pathogen growth rates from scientific experiment.

The use of a pathogen growth model provides a scalable means to apply pathogen growth rate prediction to produce shipments globally, thus providing a science-based approach to determining the safety of produce in the event of temperature excursions in the cold chain.

Hemdahl's predictive algorithms for pathogen growth, product temperature, temperature-related injury, and retail shelf life can be used for all transport modes (marine, rail, road, and air) and are independent of the reefer make, datalogger type, telematics system, etc.

HEMDAHL
Hemdahl provides a SaaS platform that analyses logged data for perishable products to provide unique, actionable insights into product quality and safety. Our mission is to make the world's perishable products safer, cutting waste and reducing carbon footprints.
More information is available at www.hemdahl.com.