UNIMORE
UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA

Centro Interdipartimentale per il Miglioramento e la Valorizzazione delle Risorse Biologiche Agro-alimentari BIOGEST-SITEIA

Packaging-Dependent Primary and Secondary Shelf-Life Prediction and Validation

Shelf-life assessment is a standard practice in the food industry, primarily because food manufacturers are required to indicate the **minimum durability date (MDD)** on product labels, which applies to products stored in hermetically sealed packages. For products that are sensitive to moisture transfer, the **primary shelf life (PSL)** can be estimated using mathematical models that relate changes in product moisture content to the moisture barrier properties of the packaging material. Likewise, the **secondary shelf life**, which refers to the storage period after package opening, can also be predicted using mathematical models that account for the time at which the package is opened. The service provides an effective decision-support tool that enables companies to identify the most suitable packaging solutions and streamline product development.

"Predict Shelf Life Before Testing"

Laboratory	BIOGEST-SITEIA
Specialization Area	Agrifood
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Keyword	shelf life, packaging, modelling, bakery products



Fig. 1: Breadsticks primary packaging



Fig. 2: Breadsticks' primary and secondary packages

Description

The service consists of a consultancy provided to food companies aiming to rapidly predict the shelf life of their products following changes in packaging materials, package geometry (surface area-to-volume ratio), or product formulation. The consultancy comprises an initial phase dedicated to collecting the input data required for the mathematical model, including the barrier properties of the packaging, storage conditions, and the physicochemical characteristics of the food product. Once the necessary data have been collected or generated through laboratory analyses, the second phase involves modelling the primary shelf life and, where applicable, the secondary shelf life. These predictive models enable food manufacturers to rapidly evaluate the impact of changes in packaging materials and product formulation, thereby reducing the time, costs, and number of experimental trials required for shelf-life determination and validation. An optional third phase consists of conducting accelerated shelf-life studies to validate the model predictions experimentally.

Innovative aspects

The key innovative of this service lies in providing food companies with a practical and easy-to-use tool for predicting product shelf life without the need to perform lengthy and costly shelf-life studies. This approach is particularly valuable during the screening phase of new primary and secondary packaging materials, as well as when evaluating modifications to product formulations, either individually or in combination. The ability to identify and discard packaging solutions that are unlikely to meet the product's shelf life requirements at an early stage significantly reduces the number of experimental trials required during the industrial development and validation of new packaging and formulation solutions. The proposed model therefore serves as a decision-support tool, enabling companies to identify the most promising packaging and formulation options before undertaking more extensive experimental shelf-life testing

Potential applications

Shelf-life prediction based on simple mathematical models is potentially applicable to all food products whose stability is influenced by packaging characteristics and storage environmental conditions. At present, the main area of application is represented by low-moisture products, including foods for human consumption, pet food, animal feed, and pharmaceutical products. The predictive modelling provides an effective and reliable approach for estimating shelf life while minimizing the need for extensive experimental testing

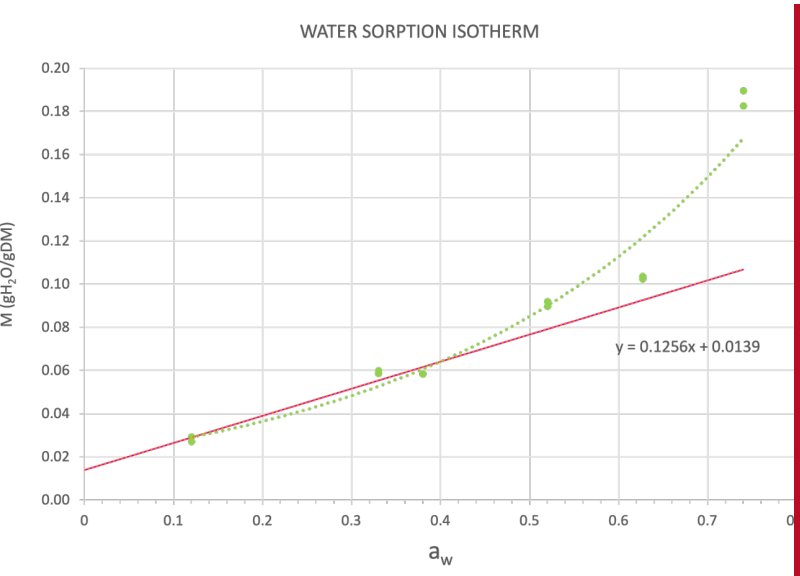


Fig. 3: Water Adsorption isotherm of breadsticks

Involved partners	BIOGEST-SITEIA, companies of the Agrifood sector
Implementation Time	1 month/person
Technology Readiness Level	TRL8 - System complete and qualified
Exploitation	Search for industrial partners to extend the application of the predictive model to additional food product

Application example

Primary and Secondary Shelf Life of Breadsticks: From Experimental Assessment to Predictive Modelling

The proposed predictive models were applied to an industrial case study involving individually wrapped breadsticks (primary packaging) enclosed within a secondary package. The product was characterized in terms of its hygroscopic behaviour by determining the water vapour adsorption isotherm, the initial moisture content, and the critical moisture content. The packaging materials were characterized according to their water vapour barrier properties, while the storage environment was set at tropical conditions (38°C and 90% relative humidity). By integrating these parameters into the proposed model, the primary shelf life (minimum durability date, MDD) was predicted with an accuracy of approximately 90%, according to data provided by the manufacturer. A second model, derived from the primary shelf-life model, was developed to predict the remaining shelf life of the individual breadstick portions as a function of the time elapsed between packaging and opening of the secondary package. In this case as well, although the model slightly underestimated the experimentally measured values obtained from shelf-life studies conducted in our laboratories, its predictions proved to be highly reliable, showing excellent agreement with the experimental data

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Website http://www.biogest-siteia.unimore.it

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