

AEPSTM

Advanced Egg Performance Systems

WHITE PAPER

INTABIOTECH SL

A next-generation technological platform for industrial egg processing. Industrial egg processing is undergoing a structural transformation driven by increasingly stringent requirements regarding process consistency, thermal robustness, microbiological stability, formulation simplification and refrigerated shelf-life management. Traditional approaches based solely on thermal processing or standard hydrocolloid/emulsifier systems are progressively insufficient to address modern industrial challenges associated with high-throughput egg processing environments.

Advanced Egg Performance Systems™ (AEPSTM) by INTABIOTECH has been developed as an integrated technological platform designed to support industrial egg-derived systems through controlled functional optimisation strategies combining food-grade enzymatic processing, functional stabilisation technologies and process-oriented refrigerated quality management. Rather than positioning enzymes as isolated technological ingredients, AEPSTM functions as a broader industrial process optimisation framework.

Foam Stability

Controlled aeration performance and drainage reduction across industrial batches

Emulsification Robustness

Phospholipid-based interfacial activity management for stable emulsion systems

Thermal Tolerance

Process-integrated heat resistance for demanding thermal manufacturing windows

Batch Consistency

Reproducible industrial output aligned with HACCP and quality management systems

i Developed under Regulation (EC) No 1332/2008 and associated EFSA guidance documents governing food enzymes and processing aids within the European Union.

1. Introduction

Egg-derived ingredients remain among the most technologically complex matrices used in modern food manufacturing. Their unique balance of proteins, phospholipids, lipoproteins and surface-active compounds enables highly diverse industrial applications spanning aerated bakery systems, refrigerated ovoproteins, emulsified sauces, confectionery, desserts, thermal gel systems and protein-enriched functional foods. No other single biological ingredient delivers this breadth of functional utility within a single matrix.

However, industrial egg systems also exhibit substantial variability that creates significant process engineering challenges. Seasonal composition changes, thermal sensitivity, protein denaturation dynamics, emulsion instability, refrigerated shelf-life constraints and process-to-process inconsistency all represent critical risk factors in high-throughput manufacturing environments. These variables are difficult to control through formulation alone and require systematic, process-level intervention strategies.

Industrial Challenges

- Seasonal composition variability
- Thermal sensitivity and protein denaturation
- Emulsion instability under process stress
- Refrigerated shelf-life constraints
- Batch-to-batch inconsistency
- Process-to-process functional variation

Modern Manufacturer Requirements

- Predictable industrial functionality
- Robust and wider processing windows
- Reduced formulation variability
- Simplified ingredient declarations
- Full compatibility with industrial HACCP systems
- Scalable, reproducible process performance

Modern manufacturers increasingly require predictable industrial functionality, robust processing windows, reduced variability, simplified formulations and full compatibility with industrial HACCP systems. AEPSTTM has been developed specifically to address these requirements through a structured, module-based technological framework that intervenes at the process level rather than relying solely on formulation-side solutions.

AEPS · Scientific Poster



AEPS™ (ADVANCED EGG PERFORMANCE SYSTEMS):

AN INTEGRATED PLATFORM FOR FUNCTIONAL OPTIMIZATION,
THERMAL STABILITY AND REFRIGERATED QUALITY
MANAGEMENT IN EGG-BASED FOOD SYSTEMS

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AEPS™

TECHNOLOGY FOR
THE FUTURE OF THE
EGG INDUSTRY

1. INTRODUCCIÓN 2. WHAT IS AEPS™? 6. INDUSTRIAL RESULTS

Egg products are key ingredients in numerous food applications. However, their functionality can be affected by natural variability, heat treatment and prolonged refrigeration, generating challenges in stability, reproducibility and useful life.

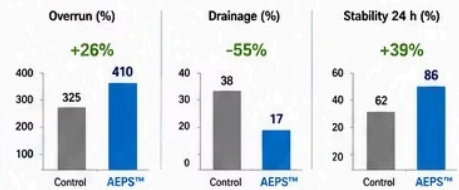
AEPS™ is an integrated technological platform that combines enzymatic and process strategies to optimize the functionality of egg-based systems in a safe and effective way.

AEPS™ (Advanced Egg Performance Systems) is a modular platform that integrates different strategies to improve the industrial performance of egg systems.

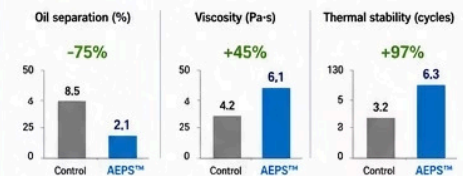


Three modules – One objective: maximum industrial performance

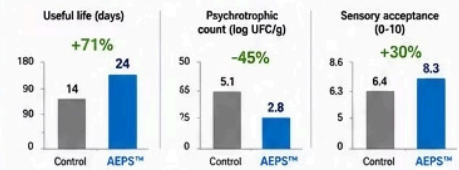
FOAMS (Pasteurized liquid egg whites)



EMULSIONS (Mayonnaise)



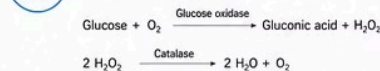
REFRIGERATED SYSTEMS (Refrigerated omelette)



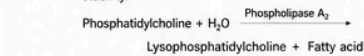
Average results obtained in industrial pilot tests

3. SCIENTIFIC BACKGROUND 4. TECHNOLOGICAL STRATEGY 7. INDUSTRIAL APPLICATIONS

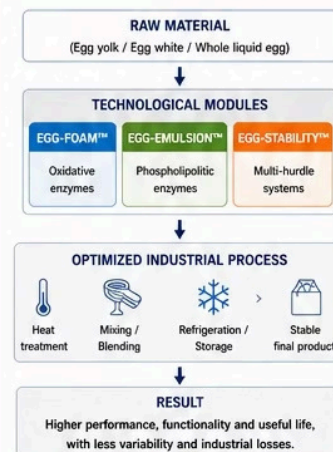
Foam optimization (EGG-FOAM™)
The glucose oxidase/catalase system reduces residual glucose and oxidative stress, improving foam capacity and stability.



Emulsion optimization (EGG-EMULSION™)
Phospholipase A₂ modifies phospholipids in the yolk, generating more surface-active lysophospholipids and improving emulsion stability.



Refrigerated stability (EGG-STABILITY™)
Temperature-controlled strategies, fermentative systems and process optimization improve microbiological and sensory stability.



7. INDUSTRIAL APPLICATIONS

- EGG-FOAM™ Foamed systems**
 - Pasteurized liquid egg whites
 - Meringues and mousses
 - Meringue powders
 - Aerosol bakery products
 - Foamed protein beverages
- EGG-EMULSION™ Emulsified systems**
 - Mayonnaises and cold sauces
 - Dressings and sauces
 - Liquid egg yolk / Whole liquid egg
 - Creams and fillings
 - UHT and HTST systems
- EGG-STABILITY™ Refrigerated systems**
 - Refrigerated omelette
 - Egg-based ready meals
 - Refrigerated desserts
 - Egg salads and fillings
 - Refrigerated bakery fillings

5. RECOMMENDED DOSAGES 8. REGULATORY FRAMEWORK (EU) 9. KEY BENEFITS OF AEPS™

MODULE	TECHNOLOGY	RECOMMENDED DOSAGE*	APPLICATION
EGG-FOAM™	Glucose oxidase	20 – 150 ppm	Clear liquid
	Catalase	Adjusted according to activity	Clear liquid
EGG-EMULSION™	Phospholipase A ₂	10 – 100 ppm	Yolk / Whole liquid egg
EGG-STABILITY™	Acidifying system	1,000 – 5,000 ppm	Refrigerated systems
	Fermentative systems	0.5 – 2%	Refrigerated systems

* Doses must be adjusted according to matrix, process and technological objectives.

- The enzymes used in AEPS™ are of food grade and comply with Regulation (EC) No 1332/2008 on food enzymes.
- AEPS™ is used as a technological adjuvant in the process.
- The enzymes are inactivated during heat treatment.
- The food operator is responsible for validation in the food matrix and process.
- No statements are made about health properties or antimicrobial properties.



- ✓ Higher functional and thermal stability
- ✓ Reduction of lot-to-lot variability
- ✓ Improved refrigerated shelf-life
- ✓ Reduction of losses and waste
- ✓ Optimization of industrial processes
- ✓ Compatible with clean label trends
- ✓ Flexible and adaptable solution



TECHNOLOGY. PROCESS. PERFORMANCE.
THE FUTURE OF EGG, TODAY.

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REFERENCES

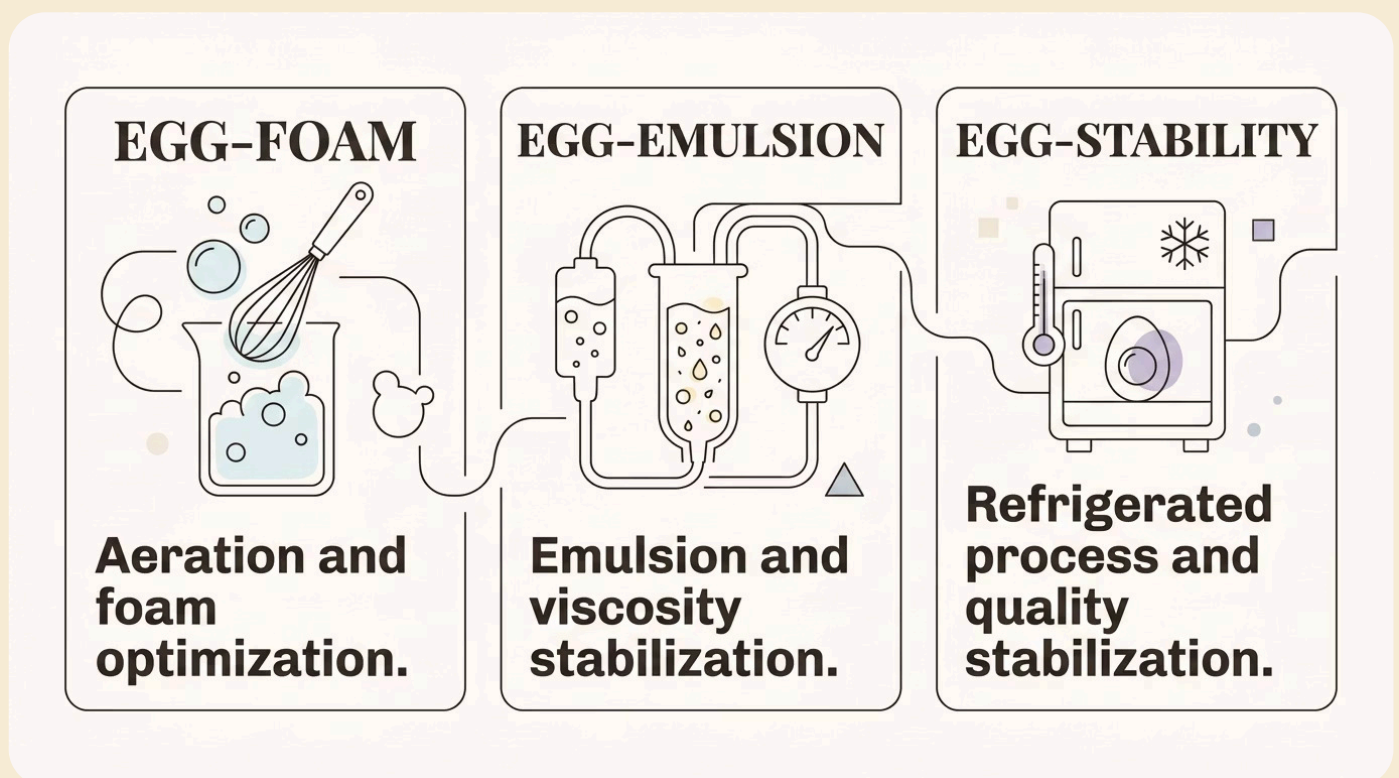
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2. Technological Foundation of AEPSTM

AEPSTM is structured around three complementary technological modules, each addressing a distinct functional domain of industrial egg processing. Rather than operating as independent ingredient systems, these modules are conceived as integrated components of a unified process optimisation architecture. The platform is designed to be deployed individually or in combination, depending on the specific manufacturing environment, product category and functional objectives of the operator.

Each module applies food-grade enzymatic and stabilisation technologies in a precisely controlled manner, targeting defined functional outcomes measurable through standard industrial KPIs. The modular architecture allows manufacturers to adopt AEPSTM progressively, validating individual module performance before full platform integration.



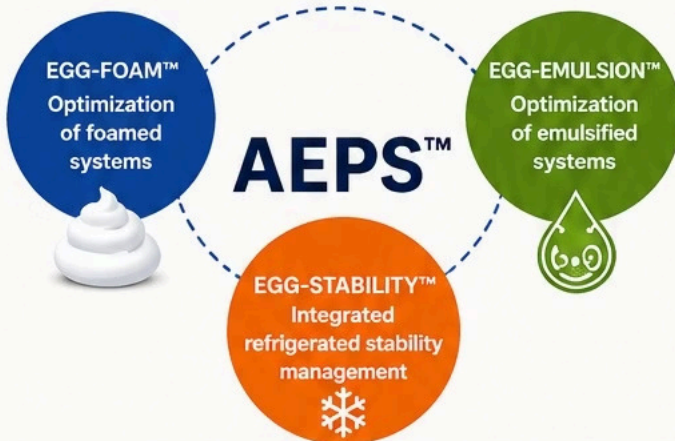
The overarching design philosophy of AEPSTM is process integration rather than ingredient substitution. The platform's value is realised not at the formulation stage, but within the manufacturing process itself — enabling operators to achieve more consistent, robust and reproducible outputs from egg-derived ingredient systems. This positions AEPSTM as a strategic industrial tool rather than a conventional food additive or preservative system.



AEPS™

ADVANCED EGG PERFORMANCE SYSTEMS™

AN INTEGRATED TECHNOLOGICAL PLATFORM FOR FUNCTIONAL OPTIMIZATION, THERMAL STABILITY AND REFRIGERATED QUALITY MANAGEMENT IN EGG SYSTEMS



KEY BENEFITS

-  Higher stability and consistency
-  Reduction of batch-to-batch variability
-  Improved refrigerated shelf-life
-  Reduced waste and losses
-  Optimization of industrial processes
-  Compatible with clean label trends
-  Flexible and adaptable solution

THREE MODULES. ONE PLATFORM. MAXIMUM PERFORMANCE.

EGG-FOAM™
Optimization of foamed systems



- Higher volume and overrun
- More stable foam over time
- Lower drainage and collapse
- Better performance in baking
- Greater consistency between batches

EGG-EMULSION™
Optimization of emulsified systems



- Lower oil separation
- Higher viscosity and body
- Improved thermal stability
- Smoother, more stable texture
- Reduced syneresis

EGG-STABILITY™
Integrated refrigerated stability management




- Longer refrigerated shelf-life
- Reduction of spoilage microorganisms
- Better sensory stability
- Lower oxidation
- Less waste and product loss

INDUSTRIAL APPLICATIONS

- 
Liquid egg whites
- 
Meringues and mousses
- 
Mayonnaise and sauces
- 
Bakery products
- 
Ready meals with egg
- 
Desserts & fillings
- 
UHT & HTST systems

 **HIGHER INDUSTRIAL PERFORMANCE**

 **GREATER STABILITY AND CONSISTENCY**

 **LONGER REFRIGERATED SHELF-LIFE**

 **CLEAN LABEL & SUSTAINABLE SOLUTIONS**

SCIENTIFIC SOLUTIONS FOR A MORE COMPETITIVE, EFFICIENT AND SUSTAINABLE INDUSTRY.

3. EGG-FOAM™ — Functional Optimisation of Aerated Egg Systems

Aerated systems based on egg white proteins represent one of the most technically demanding categories in industrial food manufacturing. These systems are highly sensitive to thermal history, pH fluctuations, protein aggregation dynamics, glucose-related Maillard reactions and mechanical shear forces introduced during processing. Any deviation in these parameters can result in compromised foam structure, increased drainage, reduced overrun and batch-level inconsistency — all of which translate directly into quality failures and economic losses at industrial scale.

AEPST™ incorporates controlled food-grade enzymatic processing strategies specifically designed to support whipping consistency, foam structure integrity, drainage reduction and improved overrun reproducibility across production batches. The platform may incorporate controlled glucose oxidase/catalase systems and/or highly controlled low-hydrolysis protein modulation approaches, selected according to the specific matrix and process conditions of each industrial operator.

- The objective is not protein degradation, but rather **controlled functional stabilisation of interfacial protein behaviour** during industrial aeration processes — a distinction of critical regulatory and technical significance.



Liquid Egg White & Meringue

Stabilised interfacial protein behaviour supporting consistent whipping performance in liquid egg white streams and industrial meringue production.



Confectionery Foam Systems

Improved overrun consistency and drainage control for marshmallow systems, protein foams and aerated dessert applications under high-throughput conditions.



Whipped Bakery Applications

Thermal robustness and batch reproducibility for whipped bakery systems requiring stable foam structures across variable thermal processing environments.



EGG-FOAM™ — Performance Targets & KPIs

Industrial validation of EGG-FOAM™ is structured around measurable functional key performance indicators that can be integrated within existing quality management and HACCP frameworks. The following parameters represent the primary functional targets for aerated egg systems processed under AEPST™ methodology. All targets reflect improvements relative to unmodified reference systems processed under equivalent conditions.



Foam Stability

Target retention rate versus unmodified reference system

Overrun Consistency

Batch-to-batch reproducibility target across production runs



Drainage Reduction

Improvement in drainage control versus standard processing

Thermal Robustness

Performance retention under elevated thermal processing conditions

Industrial target applications for EGG-FOAM™ encompass liquid egg white processing, meringue systems, whipped bakery applications, marshmallow production, protein foam systems and aerated desserts. The module is designed to interface directly with existing industrial aeration equipment and process lines without requiring significant capital investment or process re-engineering, enabling efficient operator adoption.

- ✔ EGG-FOAM™ is designed for seamless integration with existing industrial aeration equipment, requiring no significant process re-engineering for adoption.

4. EGG-EMULSION™ — Controlled Phospholipid Functionality Management

Among all AEPST™ modules, EGG-EMULSION™ currently represents the most scientifically robust and industrially mature technological approach within the platform. The module is based on controlled modification of egg yolk phospholipid functionality using food-grade phospholipase technologies — a strategy with a well-established body of industrial and regulatory evidence supporting its efficacy and safety in egg processing contexts.

The system operates through Phospholipase A₂-mediated hydrolysis of phosphatidylcholine into lysophosphatidylcholine. This biochemical conversion may significantly improve interfacial activity, emulsion stability, thermal resistance and viscosity consistency in egg yolk-based systems. Lysophosphatidylcholine produced through this controlled enzymatic pathway exhibits superior surface-active properties compared to native phosphatidylcholine, resulting in stronger and more thermally resilient interfacial films at oil-water interfaces — the fundamental mechanism underlying emulsion stability in industrial food systems.

EFSA safety evaluations have already assessed phospholipase systems intended for egg processing applications, including mayonnaise and liquid egg processing contexts, providing a robust regulatory foundation for AEPST™ deployment within the European Union. Industrial literature additionally supports the use of phospholipase technologies to improve mayonnaise heat stability, emulsion activity, viscosity, and texture robustness across diverse thermal processing environments.

Phospholipase A₂ Mechanism

Enzymatic hydrolysis of phosphatidylcholine to lysophosphatidylcholine, generating superior surface-active species with enhanced interfacial film-forming capacity.

EFSA Regulatory Validation

Safety evaluations completed for phospholipase systems in egg processing, including mayonnaise and liquid egg applications, under current EU food enzyme frameworks.

Industrial Literature Support

Extensive published evidence supporting phospholipase technology for improved heat stability, emulsion activity, viscosity control and texture robustness in commercial applications.



EGG-EMULSION™ & EGG-STABILITY™ — Applications & Targets

EGG-EMULSION™ Target Applications

- Mayonnaise and full-fat sauces
- Dressings and emulsified condiments
- Liquid egg yolk and whole egg
- Thermally processed emulsion systems
- Bakery fillings and creams

EGG-EMULSION™ Functional Targets

- Oil separation — **Reduced**
- Emulsion robustness — **Improved**
- Thermal tolerance — **Improved**
- Viscosity consistency — **Improved**
- Texture uniformity — **Improved**

5. EGG-STABILITY™ — Refrigerated Industrial Egg Systems

Modern refrigerated egg-derived foods require increasingly sophisticated multi-hurdle stabilisation approaches. Single-point preservation concepts are no longer adequate for the complexity of contemporary refrigerated egg product portfolios. EGG-STABILITY™ is designed as a process-integrated quality stabilisation framework that addresses this gap.

AEPST™ integrates functional stabilisation, process optimisation, refrigerated quality preservation strategies and food-grade technological systems compatible with industrial hygienic design principles. Potential integration areas include buffered fermentation-derived systems, cultured carbohydrate technologies, food-grade acidification support and refrigerated process stabilisation systems.

EGG-STABILITY™ Target Applications

- Refrigerated tortilla and wraps
- Liquid whole egg systems
- Refrigerated omelette products
- Egg-containing chilled fillings
- Refrigerated desserts and RTE foods

i EGG-STABILITY™ is not a single-point preservation system. It is a **multi-hurdle, process-integrated quality stabilisation framework** designed for modern refrigerated egg-derived food manufacturing environments.

6. Regulatory Framework

AEPSTM has been conceptually developed under the current European regulatory environment governing food enzymes and processing aids. Regulation (EC) No 1332/2008 established the harmonised framework governing food enzymes within the European Union, introducing a unified authorisation procedure and safety assessment process managed by the European Food Safety Authority. However, the final Union List of authorised food enzymes has not yet been fully implemented, meaning that transitional national frameworks currently remain relevant across Member States — a factor of significant practical importance for industrial operators planning commercial deployment.

Accordingly, AEPSTM has been designed around a set of foundational principles that support regulatory defensibility across both current transitional and future harmonised frameworks. These include the exclusive use of food-grade processing technologies, an industrial process support positioning rather than additive classification, processing aid positioning where applicable, validated thermal inactivation protocols, the absence of residual technological function in the final product where relevant, and operator-specific validation requirements tailored to national regulatory contexts.

1

Food-Grade Processing Technologies

All enzymatic and stabilisation systems within AEPSTM utilise exclusively food-grade processing technologies compliant with applicable EU legislation.

2

Processing Aid Positioning

Where applicable, AEPSTM components are positioned as processing aids rather than additives, minimising labelling and declaration requirements.

3

Thermal Inactivation Validation

Process protocols include validated thermal inactivation steps ensuring absence of residual enzymatic activity in thermally processed final products.

4

EFSA Guidance Compliance

Platform development aligns with EFSA guidance on production organism characterisation, toxicology, allergenicity, residual DNA, purity and exposure assessment.

⚠ The final Union List of authorised food enzymes under Regulation (EC) No 1332/2008 has not yet been fully implemented. Operators must assess applicable national transitional frameworks prior to commercial deployment in each target Member State.



FARM EGG
EMULSION
COLD-PRESSED BLEND

FARM EGG
EMULSION
COLD-PRESSED BLEND

FARM EGG
EMULSION
COLD-PRESSED BLEND

FARM EGG
EMULSION
HARVEST EDITION

FARM EGG
EMULSION
HARVEST EDITION

FARM EGG
EMULSION
HARVEST EDITION

FARM EGG
EMULSION
HARVEST EDITION
1000 ML



7. Industrial Validation Strategy

AEPSTM has been designed for implementation within established industrial validation frameworks, ensuring that platform adoption can be integrated seamlessly into existing quality management infrastructure. The system is compatible with HACCP systems, IFS Food, BRCGS, ISO 22000 and refrigerated chain validation systems — the principal certification and compliance frameworks operative across the European food manufacturing sector.

Industrial validation of AEPSTM modules is structured around functional key performance indicators specific to each technological domain. These KPIs are selected to be measurable using standard industrial analytical methods, enabling operators to generate statistically robust validation data without requiring specialised laboratory infrastructure beyond what is typically available in modern egg processing facilities. Validation is recommended to be conducted under representative industrial conditions, using production-scale equipment and commercially relevant formulations, to ensure that performance data accurately reflects real-world manufacturing outcomes.

Area	Module	Suggested KPI	Measurement Approach
Foam Systems	EGG-FOAM TM	Overrun / Drainage	Gravimetric / volumetric analysis
Emulsions	EGG-EMULSION TM	Oil separation / Viscosity	Centrifugation / rheometry
Refrigerated Systems	EGG-STABILITY TM	Microbial stability	Standard plate count / challenge testing
Thermal Systems	All modules	Heat resistance	Thermal stability protocols
Process Control	All modules	Batch reproducibility	Statistical process control (SPC)

Validation data generated through AEPSTM-aligned protocols may also support regulatory dossier preparation where enzyme or processing aid authorisation is required at national level, providing manufacturers with a structured evidentiary basis for engagement with competent authorities. INTABIOTECH supports operators through the validation design and protocol development phase to ensure that generated data meets applicable regulatory and commercial standards.

8. Strategic Positioning

The strategic positioning of AEPSTM is a critical dimension of its commercial and regulatory design. The platform is **explicitly not positioned as an additive platform, a preservative system or an "enzyme ingredient"** in the conventional industrial sense. Each of these positionings carries specific regulatory, commercial and perception-related constraints that would limit the platform's industrial applicability and market differentiation potential.

Instead, AEPSTM is positioned as **"Advanced Industrial Egg Performance Technology"** — a designation that reflects the platform's process-integrated architecture, its multi-module functional scope and its alignment with the broader trend towards industrial process optimisation rather than ingredient-level intervention. This distinction is not merely semantic; it carries substantive regulatory and commercial consequences that directly affect the platform's value proposition to industrial operators.

Reduced Regulatory Exposure

Process technology positioning minimises exposure to food enzyme authorisation requirements where processing aid status can be substantiated, reducing time-to-market and regulatory risk.



Avoids Ingredient Commoditisation

Platform positioning prevents the commercial degradation associated with ingredient commoditisation, preserving differentiated value across competitive industrial markets.

Industrial Process Value

Focus on process-level value creation rather than isolated ingredient functionality aligns with purchasing decision frameworks in large-scale industrial food manufacturing environments.



Multinational Process Alignment

Positioning aligns with global process optimisation trends among multinational food manufacturers, enabling strategic engagement with large-scale industrial clients.



9. Conclusion

Industrial egg processing is evolving toward increasingly complex manufacturing environments requiring process robustness, functional consistency, refrigerated quality management, advanced thermal stability and formulation efficiency. The convergence of these demands creates a structural gap that neither conventional additive systems nor isolated enzymatic ingredients can adequately address. AEPSTM represents a next-generation process-oriented technological platform designed to fill this gap by supporting industrial manufacturers seeking improved performance across highly dynamic egg-derived food systems.

Its value proposition does not rely on aggressive preservation claims or isolated ingredient functionality, but rather on integrated technological control, industrial consistency, process optimisation and scientifically structured validation approaches. This positions AEPSTM as a strategic industrial framework rather than a product — one whose adoption delivers compounding process-level benefits across foam stability, emulsification robustness, thermal tolerance and refrigerated quality management simultaneously.

Integrated Technological Control

Multi-module platform architecture delivering coordinated functional optimisation across the full spectrum of egg-derived industrial applications.

Industrial Consistency

Batch-to-batch reproducibility and process robustness as measurable industrial outcomes, validated within standard quality management frameworks.

Process Optimisation Focus

Platform-level value creation at the process engineering level, rather than formulation-side ingredient addition — a fundamentally different and more defensible industrial proposition.

In this context, AEPSTM may represent a relevant strategic framework for the future evolution of industrial egg processing technologies — one that aligns technical innovation with regulatory defensibility and commercial differentiation.

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- EFSA – Phospholipase A₁ Safety Evaluation
- EFSA – Scientific Guidance for Food Enzyme Dossier Preparation
- Nagase – Phospholipase A₂ Industrial Applications Documentation

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