

IntaBiotech

Enzyme Technology

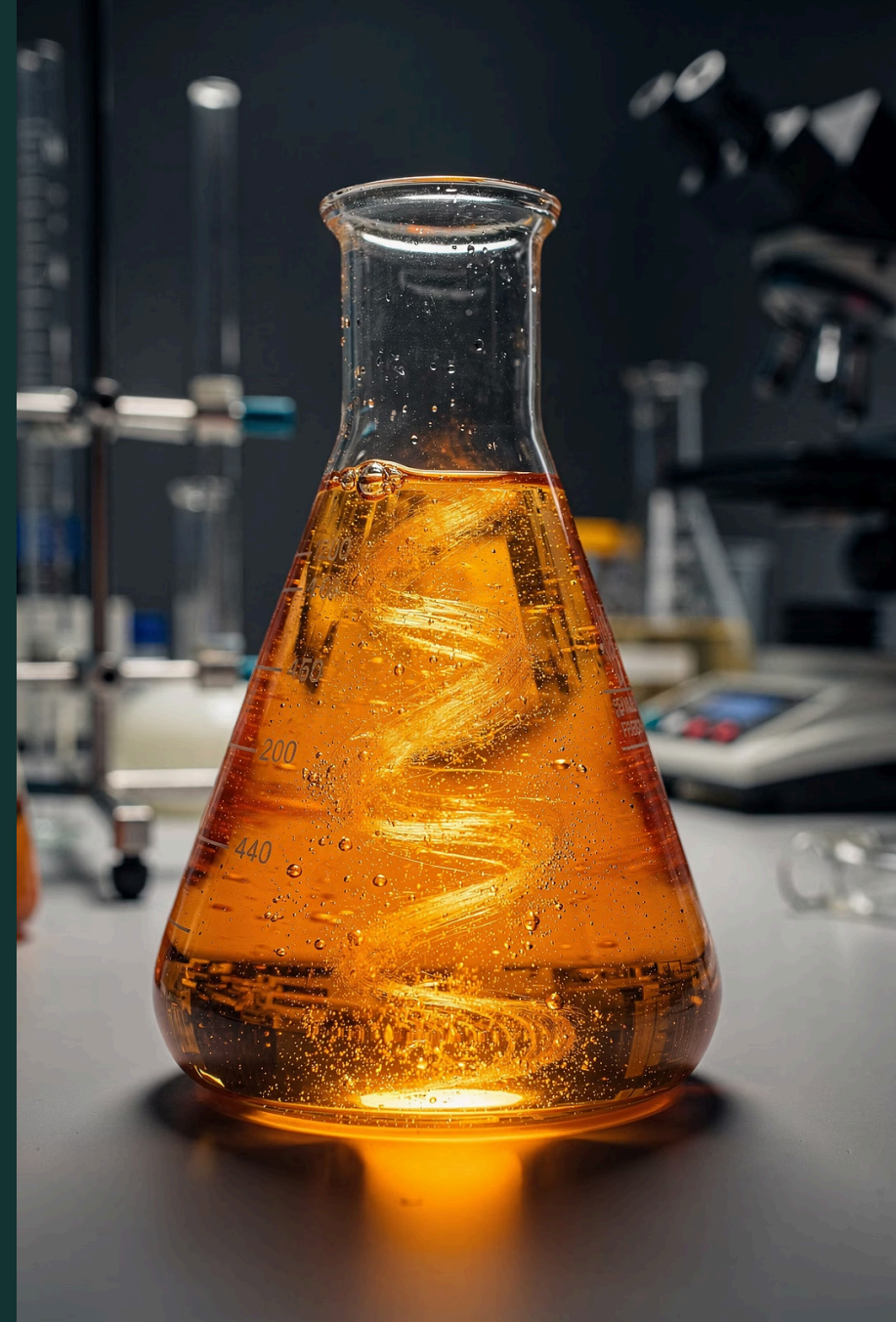
# Enzymes for the Future

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# Enzymes for the Future

The horizon of enzymatic products in the food and nutrition of tomorrow

TECHNICAL DEPARTMENT · INTABIOTECH



# Executive summary

Enzymes have evolved from invisible auxiliaries to become a **central technological platform** in contemporary food production. Their value lies in redesigning processes, improving functionality, reducing losses, and modulating texture, digestibility, stability, and sustainability.

## Regulatory framework

Regulation (EC) No. 1332/2008,  
EFSA evaluation and the  
forthcoming Union List.

## Key distinction

Technological enzymes vs.  
digestive enzymes vs. metabolic  
cofactors vs. novel foods.

## Positioning

The enzyme as an interface between biotechnology, precision nutrition, and the circular economy.



# From invisible auxiliary to strategic technology

## Before

Chymosin, amylases, pectinases, lactase, proteases, lipases: silent tools of the bakery, the dairy or the brewery. The industry knew they worked, but rarely placed them at the centre of strategic discourse.

## Today: structural tension

Consumers are demanding more natural, digestible and sustainable products. Manufacturers need stability, performance and regulatory compliance. **The enzyme sits at exactly the intersection between both worlds.**

The sector is moving towards **integrated enzyme platforms**, not towards isolated enzymes sold as commodities.

- ❏ Critical distinction: food enzyme (technological function) ≠ digestive enzyme (human consumption) ≠ metabolic cofactor (supplement) ≠ novel food (prior authorisation required).

# What is an enzyme, really?

An enzyme is a **proteinaceous biological catalyst** that accelerates specific chemical reactions without being consumed. It works under mild conditions of temperature, pH, and pressure, with high specificity for substrate, bond, position, and stereochemistry.



## Molecular precision

An amylase transforms starch without destroying proteins; a lactase hydrolyses lactose without altering the entire dairy matrix.



## Very low dosage

Acts without adding significant matter to the final product. Can be inactivated by heat or pH: the basis of its positioning as a processing aid.



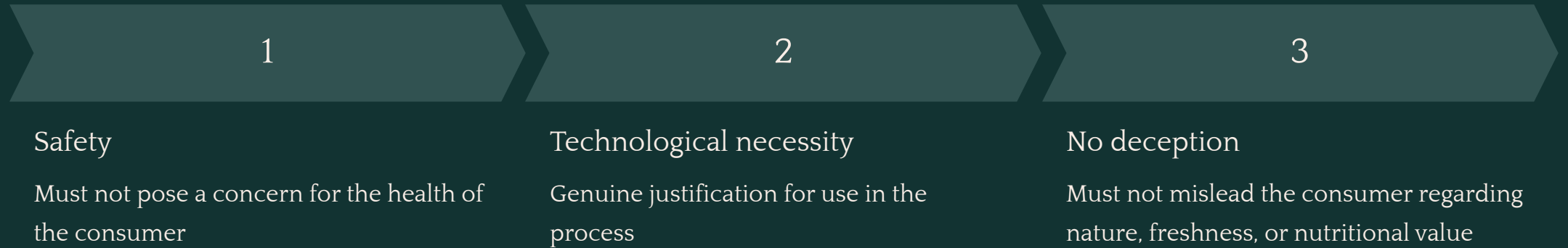
## Modern evaluation

Not merely "which reaction does it catalyse", but origin, producing organism, manufacturing process, residues, consumer exposure, and allergenic uncertainties.



# The European Legal Framework

The **Regulation (EC) No 1332/2008** harmonised the rules on food enzymes in the EU. Three cumulative conditions are mandatory:



## Europe

The Union List **has not yet been fully established**. Uses are governed by national legislation until the pending EFSA assessments are concluded. Country-by-country analysis is required.

## United States

Many enzymes are classified as authorised food additives or **GRAS** (Generally Recognised as Safe) substances. This does not equate to automatic authorisation transferable to the EU.

# From selling enzymes to selling industrial performance

The customer does not buy a protease, a lipase, or an amylase. They buy a solution to a process problem.

## Commodity enzyme

Competes on price, declared activity, and stability.  
Becomes commoditised against large global producers.

## Enzymatic platform

Competes on outcome: greater yield, lower variability, improved texture, reduced waste, controlled shelf life, and documentation that can be defended in audits.

The clearest example is **AEPS(TM) (Advanced Egg Performance Systems)**: an integrated platform for industrial egg systems with modules **EGG-FOAM(TM)**, **EGG-EMULSION(TM)** and **EGG-STABILITY(TM)**. *Less flat catalogue, more validatable technological architecture.*



# Principal Enzyme Families



## Carbohydrases

Amylases, xylanases, pectinases, lactases. They modulate fermentability, volume, texture, juice clarification, starch saccharification, and functional sweetness.



## Proteases

Meat tenderisation, protein hydrolysates, improved solubility, reduction of allergenicity, and bioactive peptides. The challenge: controlling the degree of hydrolysis to avoid bitterness.



## Lipases and Phospholipases

Structured fats, dairy aromas, cheese maturation, stable emulsions. Phospholipases are key in yolk-based systems, mayonnaise, and liquid egg.



## Oxidoreductases

Glucose oxidase, catalase, laccase, transglutaminase. They modify structure, oxidation, cross-linking, colour, and stability. They require validation of function, dosage, and inactivation.

# Enzymes and *clean label*: a real opportunity, not a free pass

Enzymes fit well within the *clean label* movement because many act during processing and do not remain active in the final product. However, equating "enzyme" with "natural, harmless, and non-declarable" would be a **technical and legal error**.

## 1 Variable origin

They may be derived from genetically modified microorganisms, animal, or plant sources, with implications for allergens, halal, kosher, vegan, and novel food.

## 2 Processing aid ≠ automatic

Processing aid status depends on the use, country, matrix, residual function, and applicable legislation – not solely on the supplier's intention.

## 3 A defensible position

"Enzymes because they enable more precise, efficient, reproducible, documentable, and sustainable processes" – not because they are "natural".



# Convergence with Precision Fermentation, AI and Enzymatic Design



The value lies not in "having enzymes", but in translating them into **measurable process indicators**: overrun, drainage, viscosity, thermal stability, oil separation, refrigerated shelf life and reduction of losses. AEPS™ is the conceptual model underpinning this logic.

# Enzymes and the Nutrition of Tomorrow

## New frontier: digestibility

Nutritional quality is no longer defined solely by grams of protein or fibre. What matters is **bioavailability, digestibility, gastrointestinal tolerance, glycaemic impact, and microbiota.**

## Key applications

- **Plant proteins:** enzymatic hydrolysis improves solubility and reduces antinutritional factors
- **Cereals and legumes:** phytases release phosphorus; alpha-galactosidases reduce flatulence
- **Senior nutrition:** high-density proteins with good digestive tolerance
- **Controlled hydrolysates:** fermented matrices for populations with reduced digestive capacity

☐ The senior population does not just need "more protein": they need protein they can chew, digest, absorb, and use metabolically, in sensorially acceptable formats.

# Digestive enzymes and "Nutra-Enzymes" from ND Pharma: opportunity with rigour



## Digestive enzymes

Lactase, alfa-galactosidase, pancreatin, bromelain, papain. Clear support in exocrine pancreatic insufficiency and lactose intolerance. Outside these uses, the evidence is more heterogeneous. *Claims* such as "improves digestion" or "reduces bloating" may be problematic if they are not authorised.



## Metabolic cofactors

NAD<sup>+</sup>, NADH, NMN, NR, PQQ, glutathione, alpha-lipoic, SAME: **these are not enzymes**, but rather coenzymes, precursors or metabolites. NMN: EFSA published a favourable opinion in May 2026 (up to 300 mg/day in adults), but a favourable opinion ≠ automatic commercial authorisation.

IntaBiotech maintains the "Nutra-Enzymes" concept, but **separates documentation into four folders: digestive enzymes, technological enzymes, coenzymes/metabolites and novel foods.**



# Enzymes and sustainability: real circularity

Enzymes enable gentler processes, higher extraction yields, lower energy consumption and **valorisation of by-products**: husks, wheys, bagasses, pulps, brans, egg membranes and vegetable residues.



## Lower energy

Gentler processes, lower hydrolysis severity, partial substitution of chemical treatments



## Circular economy

By-products converted into functional ingredients through hydrolysis, fermentation or enzymatic extraction



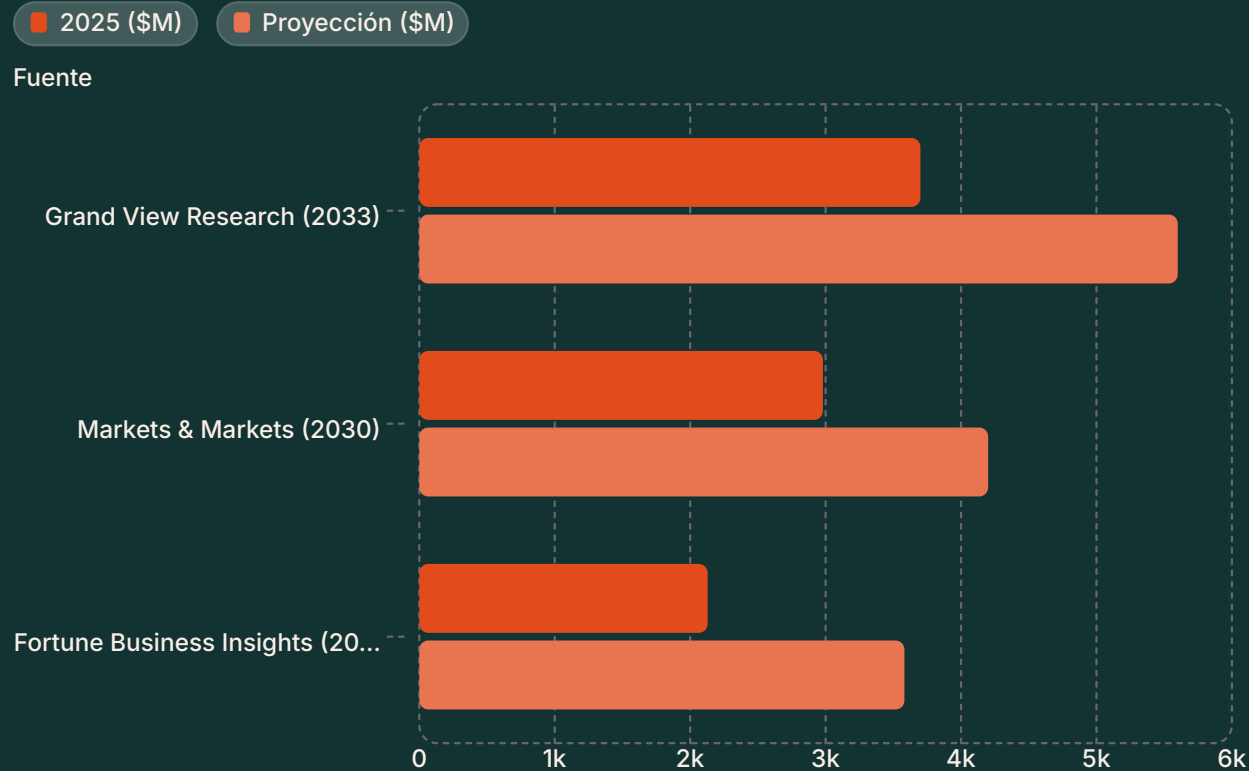
## Higher yield

In juices, starches, oils, proteins and animal feed: more useful product per unit of raw material



The fact that something originates from a by-product does not automatically make it sustainable, safe or legal. Circularity requires safety, traceability, microbiological control and regulatory compliance.

# Global market: solid and sustained growth



## Correct reading

All sources point to **sustained growth** driven by bakery, lactose-free dairy, alternative proteins, clean label, and industrial efficiency.

Estimated CAGR: **5.6% – 7.2%** depending on source.

Global industrial enzymes (detergency, biofuel, textile): projection of **\$12,010M in 2030** (MarketsandMarkets).

## ⚠️ Technical Note on the Market

Pure trading is being *commoditised*. The differential opportunity lies in technical selection, combined formulation, industrial validation, and documentary safeguarding.

# Risks that must not be underestimated

1

## Over-generalisation of function

An enzyme that works in one matrix may not work in another. pH, water activity, salt, fat, and natural inhibitors can destroy the expected effect.

2

## Uncontrolled residual activity

An enzyme that remains active after packaging can cause softening, turbidity, flavour changes, or unstable shelf life. Inactivation validation is a condition of technological safety.

3

## Allergenicity

Enzymes are potentially allergenic proteins. Occupational exposure to dust can pose a respiratory risk. EFSA considers allergenicity in every safety evaluation.

4

## Producing organism

Saying "fermentation" is not enough. Taxonomy, strain, history, absence of toxigenicity, and antimicrobial resistance must all be identified. QPS helps, but does not replace product evaluation.

5

## Improper claims

Technological enzymes do not authorise health claims. Coenzymes cannot be communicated as treatments or clinical anti-ageing. The EU Register is the public reference.

6

## Documentary risk

Incomplete data sheets, generic specifications, or SDS that do not resolve origin, allergens, GMO status, or legal standing. **Selling without a dossier is selling risk.**

# IntaBiotech Strategy: Six Platforms

The opportunity lies not in competing with the giants of enzymatic production, but in occupying the space of **technical-regulatory-commercial integrator**.



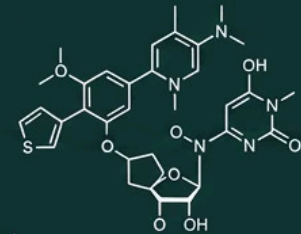
**1) Food Process Enzymes** - panadería, lácteos, bebidas, huevo, cárnicos, proteínas alt.



**2) Enzymatic Protein Nutrition** - hidrolizados, péptidos, nutrición senior, deportiva.



**3) Digestive Enzyme Supplements** - lactasa, alfa-galactosidasa, mezclimentario.



**4) Metabolic Cofactors & Nutra-Enzymes** - NADH, 5-MTHF, PQQ, glutatión.



**5) Enzymatic Circularity** - valorización de subproductos agroalimentarios.



**6) Industrial Performance Systems** - AEPS, KPIs y soporte regulatorio.

**3) Digestive Enzyme Supplements** - lactasa, alfa-galactosidasa, mezclas específicas.



# From the Reference Catalogue to the Map of Problems Solved

A food industry client does not want to study 80 enzymes; they want to solve foam drainage, oil separation, short shelf life, poor texture, or instability in plant-based drinks.



## Dairy and Egg

"System for lactose reduction with controlled sweetness" · "System for liquid egg and stable emulsions"



## Alternative Proteins

"System for controlled hydrolysis of pea protein without bitterness" · "System for more stable plant-based drinks"



## Bakery

"System for improving volume and shelf life in frozen bakery with validation protocol and audit data sheet"

# The 2030–2040 Horizon: Five IntaBiotech Transitions



## From supplier to validation partner

Whoever delivers product + protocol + validation + documentation + regulatory support will defend their margin against those who only deliver product.



## General nutrition → adapted nutrition

Digestive enzymes, hydrolysates and cofactors for seniors, athletes, intolerances, plant-based and special dietary needs.



## Clean label → clean process

It will no longer be sufficient to declare fewer ingredients; it will be necessary to demonstrate safer, more efficient, sustainable and transparent processes.



## Invisible processing aids → auditable technologies

Clients will demand origin, strain, activity, inactivation, allergens, GMO status, purity and compliance. The technical dossier will be visible.



## Generic enzymes → matrix-designed enzymes

A protease for collagen ≠ for pea ≠ for whey ≠ for insect.  
Catalytic specificity adapted to each application.



# Conclusion

Enzymes are one of the most important technologies for the food and nutrition of the future, but their true potential requires abandoning two oversimplifications:

## ✗ Oversimplification 1

Thinking that an enzyme is merely a technical ingredient.

## ✗ Oversimplification 2

Thinking that everything "enzymatic" belongs to the same scientific and regulatory category.

The advantage will not lie in promising more than science allows, but in **demonstrating more than the competition documents.**

For IntaBiotech: build platforms by application, rigorously separate regulatory categories, accompany each product with a technical dossier, and make **industrial validation a central part of the value proposition.** The enzymatic horizon is not a trend: it is an architecture for the future.

# Bibliography and Selected Sources

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## European Regulatory Framework

Regulation (EC) No 1332/2008 · European Commission (Union List, EFSA criteria) · Regulation (EC) No 1924/2006 (nutritional and health claims)

02

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## EFSA

Dossier procedure and Food Enzyme Intake Model · QPS system (micro-organisms in the food chain, triennial opinion January 2026) · Novel food opinion on  $\beta$ -NMN, May 2026

03

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## FDA

Partial list of authorised or GRAS food enzymes (21 CFR) · GRAS framework for substances generally recognised as safe

04

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## FAO and Scientific Literature

Precision fermentation and safety by design · Kumar et al. (2024): microbial enzymes in food · Precup et al. (2024): novel foods and by-products (Frontiers in Nutrition)

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## Market Data and IntaBiotech Sources

Grand View Research · MarketsandMarkets · Fortune Business Insights · IntaBiotech: Markets, Nutra-Enzymes, AEPSTM Advanced Egg Performance Systems

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