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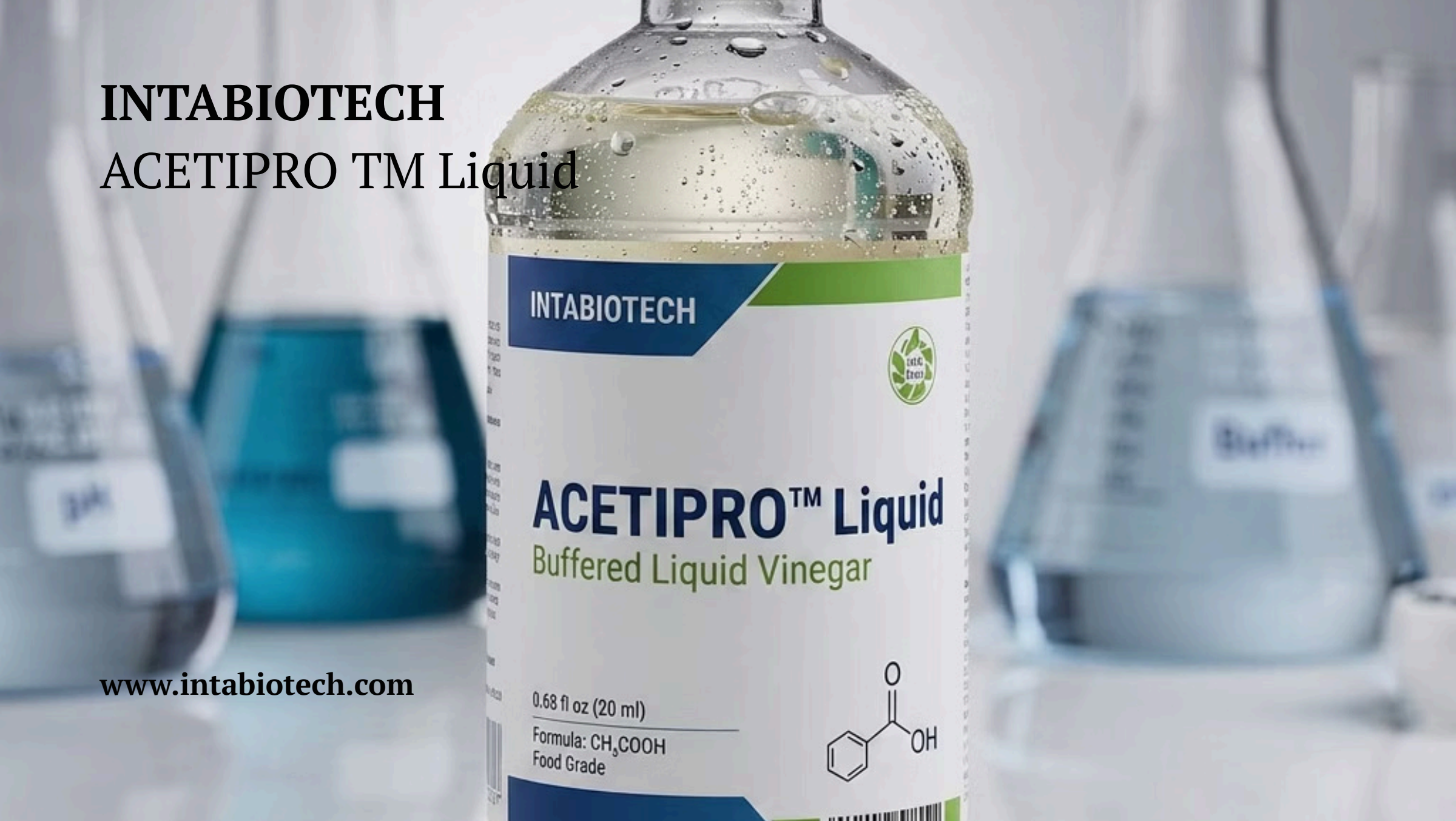
ACETIPRO TM Liquid



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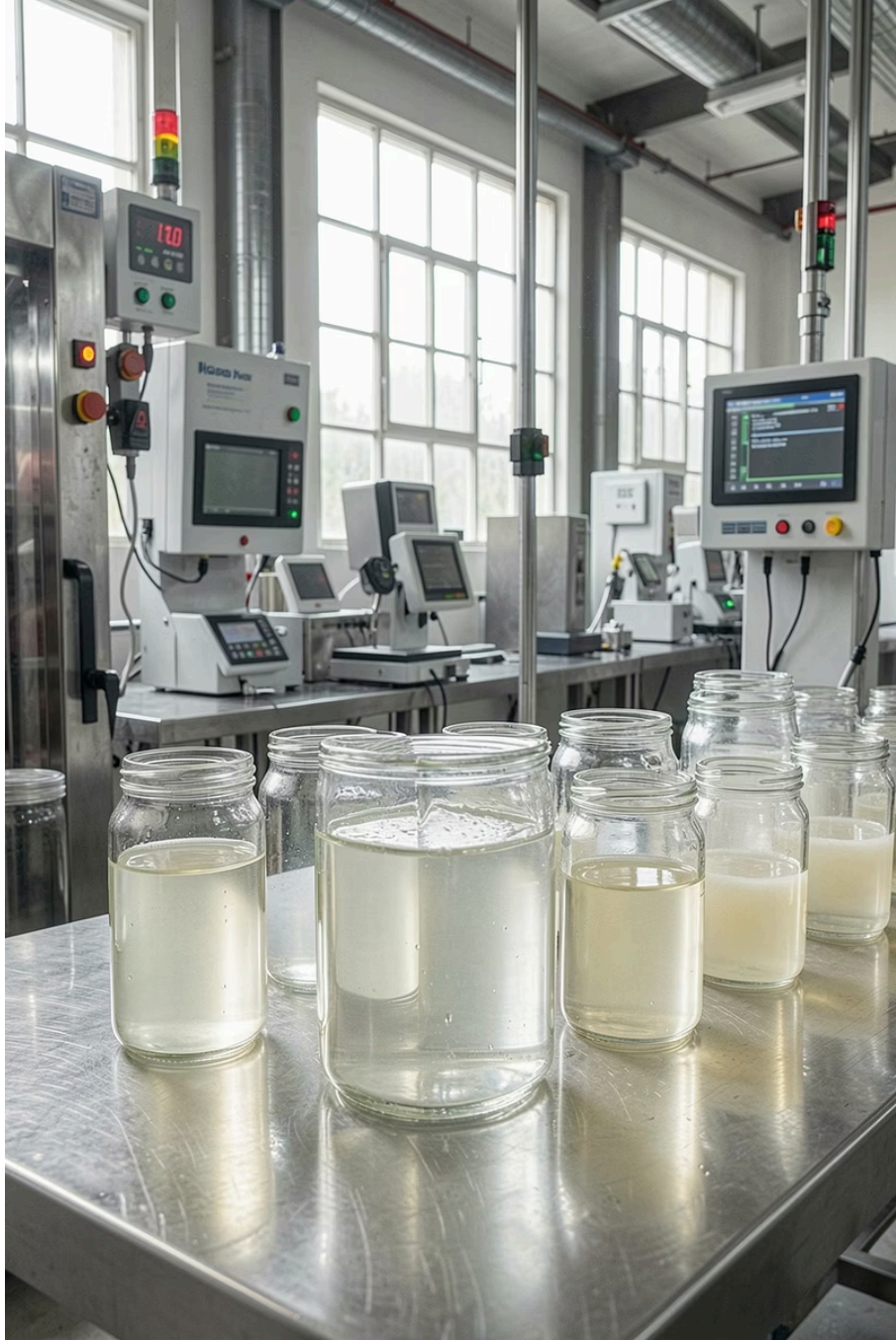
ACETIPRO™ Liquid and the New Engineering of Acetate in Food Preservation

Functional concentration, industrial efficiency, and the real economics of buffered vinegar. From traditional vinegar to high-efficiency acetic–acetate systems for shelf-life design in foods and meat preparations.

Technical & R&D Department · IntaBiotech



Executive Summary

Vinegar is one of humanity's oldest preservation tools. However, its technological interpretation remains conditioned by a culinary perception of the product. In contemporary food manufacturing, the function of the acetic system extends well beyond simple pH reduction.

The authorisation of buffered vinegar as additive **E 267** in the European Union has legally consolidated a distinct technological category. The specification expressly distinguishes between **acetic acid equivalents (AAE)** and free acetic acid — an analytical difference of considerable comparative relevance.

In this context, **ACETIPRO™ Liquid** is analysed — a liquid formulation with an acetic acid content of **18–20%**, particularly noteworthy when compared to powdered products whose declared free acidity typically falls within the 4–7% range.

Chemical Basis

Concentration, dissociation, pH, buffering capacity, and microbial physiology.

Regulatory Framework

E 267, Regulation (EU) 2023/2086, Regulation (EC) No 1333/2008.

Functional Economics

Cost per tonne of food product, not price per kilogram of ingredient.

Keywords: ACETIPRO™, buffered vinegar, E 267, acetic acid, acetate, food preservation, shelf life, *Listeria monocytogenes*, hurdle technology, functional cost.

CHAPTER 1 · INTRODUCTION

Vinegar is not merely an acidulant

The preservation of food using vinegar predates food microbiology by centuries. The most elementary interpretation — *vinegar preserves because it reduces pH* — contains truth, but is scientifically incomplete.

Breidt, Hayes and McFeeters studied the effect of pH and acetic acid on the survival of *Escherichia coli* in model systems of acidified brines. D-values were **two to four times lower** in the presence of acetic acid than when the effect attributable solely to pH was examined. The chemical identity of the acid and its concentration are independent variables of considerable significance.

Acetic acid is a weak organic acid whose equilibrium is represented by:

$$CH_3COOH \rightleftharpoons H^+ + CH_3COO^- \quad (pKa \approx 4{,}76)$$

The undissociated molecular form is of particular microbiological interest owing to its capacity to traverse cell membranes. Roe et al. demonstrated **substantial accumulation of weak acid anions** in the cytoplasm of *E. coli* and a marked disruption of cellular anionic equilibrium. Pinhal et al. showed that inhibition by acetate persists even when certain assimilation pathways are blocked, indicating additional systemic effects.

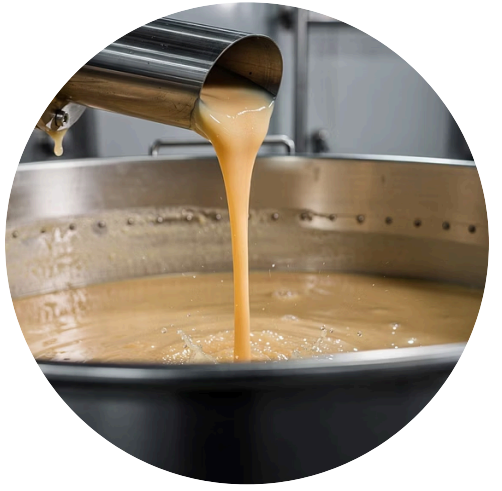
Two foods with identical pH may not exhibit identical microbiological stability. The acetic system is not solely an instrument for 'lowering the pH'.

From Conventional Vinegar to Buffered Vinegar

Conventional vinegar contributes acidity, aroma, and gastronomic identity. Its technological limitation arises when the function shifts from sensory to preservative: increasing the dose simultaneously raises acetic pressure *and* organoleptic intensity.

Conventional vinegar

Sensory function and microbiological barrier are linked. Increasing the dose results in greater organoleptic impact. Suitable for marinades, pickles, and seasoning applications.



Buffered vinegar E 267

Prepared by incorporating sodium or potassium hydroxides and carbonates into vinegar. Liquid pH: 4.75–7.5. Allows partial separation of acetic load from acidification intensity.

ACETIPRO™ Liquid

A liquid system for the industrial delivery of the acetic acid–acetate combination. Its objective is not to replicate the culinary function of vinegar, but to harness vinegar chemistry as a technology.

CHAPTER 3 · REGULATORY FRAMEWORK

E 267 and the Legal Recognition of a Differentiated Technology

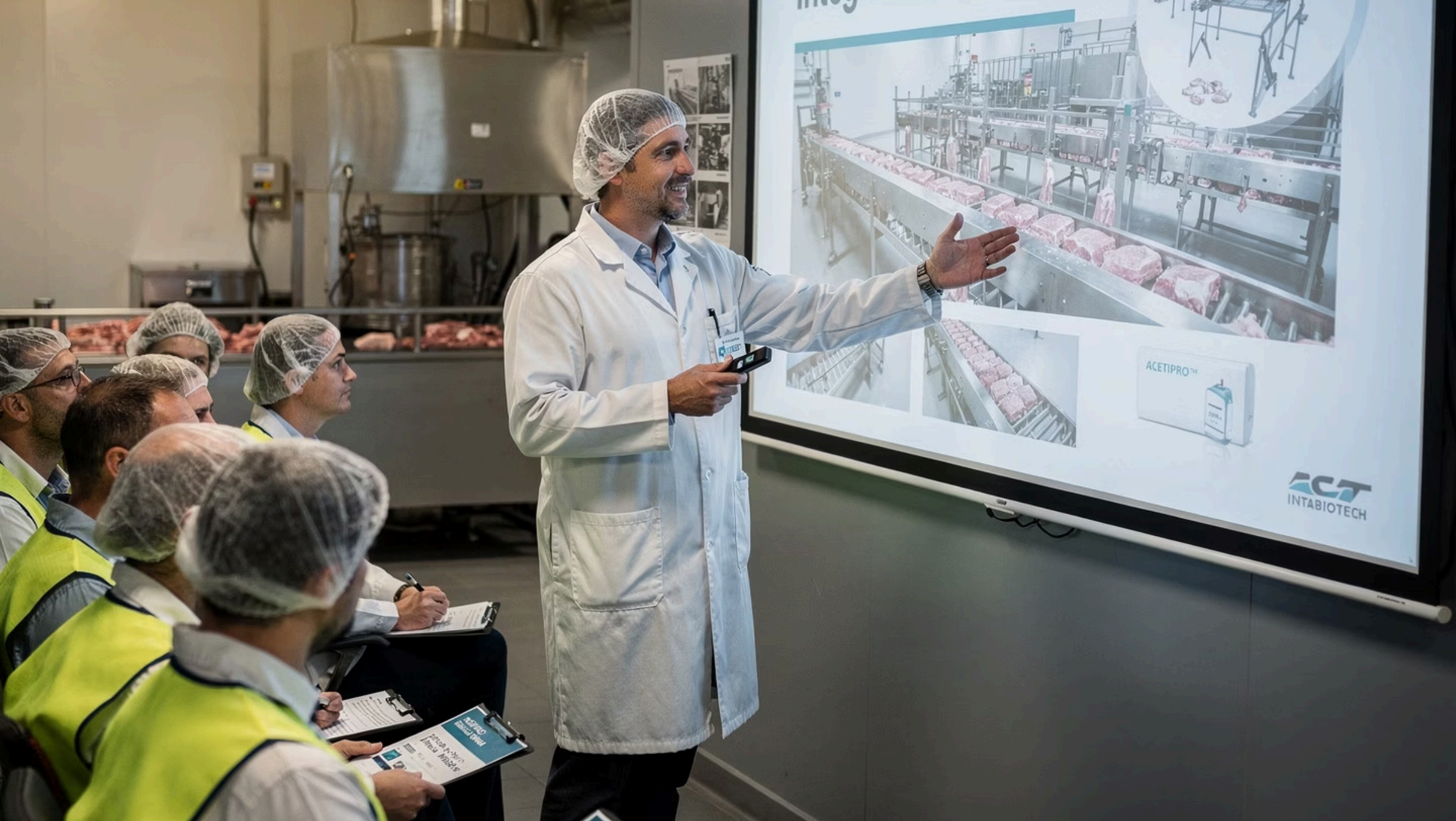
Regulation (EU) 2023/2086 incorporated buffered vinegar into the European list of food additives under the number **E 267**, recognising its function as a **preservative and acidity regulator**. It was included in Group I of additives at *quantum satis* with additional specific entries in certain categories.

The regulatory framework requires careful interpretation. Admissibility must be verified for each specific category in the current Annex II of Regulation (EC) No 1333/2008. The specific entries incorporated in 2023 include:

- Mozzarella and whey cheese
- Fruits and vegetables in tins or jars
- Fresh pasta, fresh pre-cooked pasta, and fresh refrigerated potato gnocchi
- Certain categories of bread
- Meat preparations (under defined conditions)

Key Conceptual Consequence

When the buffered system is used intentionally to perform a preservative or acidity-regulating function, it falls within the legal logic of food additives. The commercial image of vinegar as a 'natural' ingredient does not remove the technological function actually performed.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CHAPTER 4 · ANALYTICAL COMPARISON

Acetic acid equivalents and free acetic acid: the comparison begins in the laboratory

The European specification for E 267 distinguishes two concepts that are far too often confused in commercial documentation.

Acetic acid equivalents (AAE)

Express the total acetic capacity of the system, including both free acid and that associated with its salts. Liquid specification: **15–40 % m/m**. Powder: **55–75 % m/m**.

Free acetic acid

The unneutralised acid fraction present in the product. Specification: **2–20 % m/m**. ACETIPRO™ Liquid: **18–20 %**. Some commercial powder products: **4–7 %** (according to publicly available technical documentation from manufacturers).

3.6–4×

More acetic acid per kg

Nominal ratio of ACETIPRO™ (18–20 %) versus a reference at 5 % on an identical analytical basis.

4.5–5×

Versus reference at 4 %

The nominal ratio increases when the declared free acidity of the benchmark is lower.

2.6–2.9×

Versus reference at 7 %

Even at the upper end of the benchmark range, the difference remains highly significant.

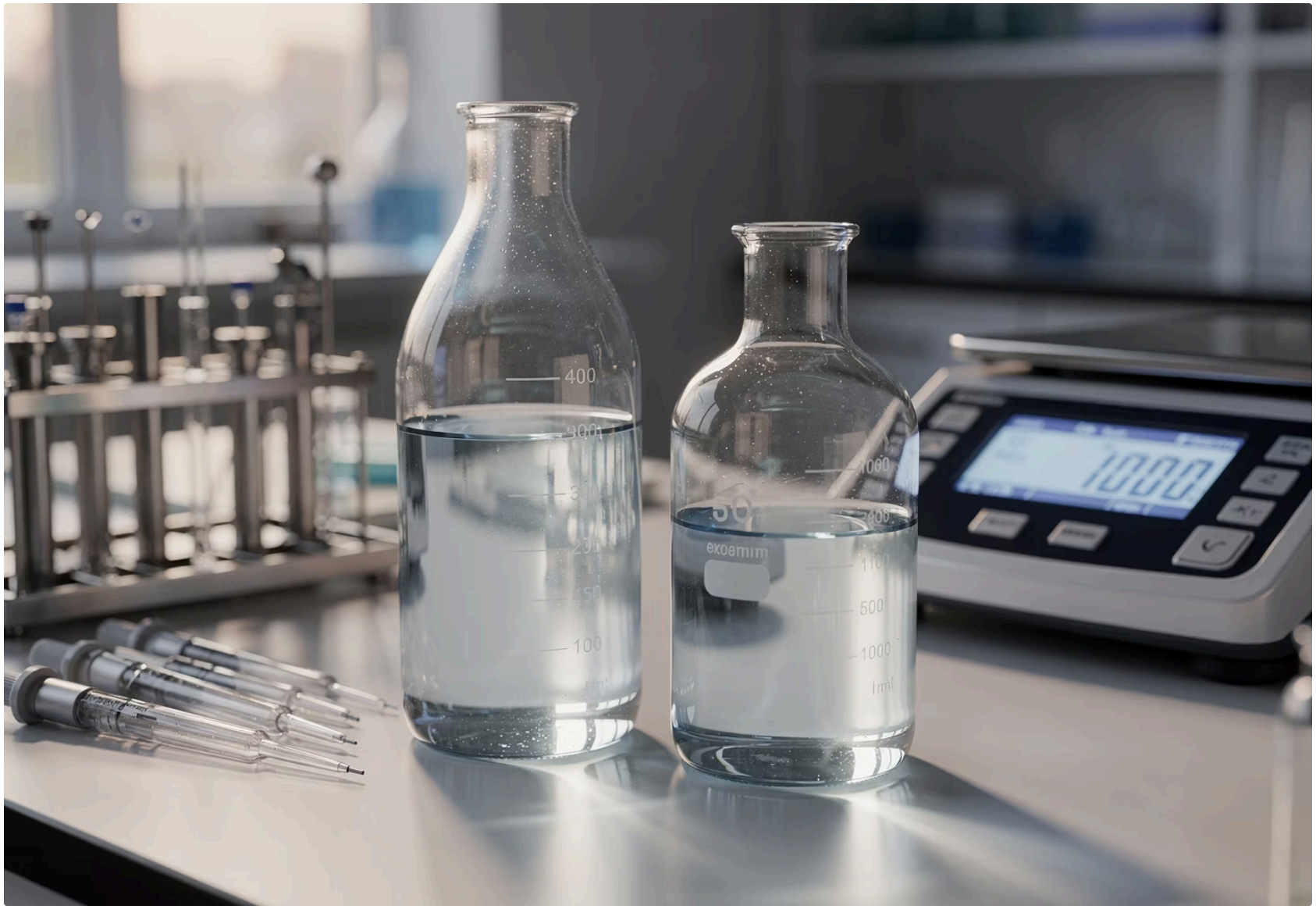
⚠ Higher concentration does not automatically equate to proportionally greater microbiological efficacy. It does, however, imply a very significant difference in the commercial mass required to deliver a nominally equivalent acetic load.

CHAPTER 5 · CONCENTRATION AS EFFICIENCY

ACETIPRO™ Liquid: concentration as an instrument of efficiency

There is an intuitive tendency to assume that a more concentrated product is necessarily "more aggressive". In formulation engineering, the opposite is frequently true: **concentration allows the dose of commercial product to be reduced**.

If ACETIPRO™ contains 20% acetic acid compared to 5% in a second product, the theoretical dose required to deliver the same nominal mass of acid would be **four times lower**.



CHAPTER 6 · FORMULATION ECONOMICS

The industry is comparing the wrong price

One of the most common shortcomings in the procurement of technological ingredients is the use of **price in €/kg** as the primary indicator of competitiveness. The figure is necessary for purchasing purposes, but proves *insufficient* for food technology.

1

Level 1

Acquisition price
€/kg of commercial product

2

Level 2

Cost of incorporation
€/t of food produced

3

Level 3

Real functional cost
€/t of food to achieve the defined technological result

Taking, as a mathematical model, ACETIPRO™ at 18–20% compared with a product at 5% on an identical analytical basis, and assuming furthermore that the powdered product costs three times more per kilogram:

$$3{,}6 \times 3 = 10{,}8 \quad \text{y} \quad 4 \times 3 = 12$$

The potential cost per acetic unit of the benchmark could be between **10.8 and 12 times** higher than that of ACETIPRO™ in that scenario.

The rigorous assertion is not "ACETIPRO™ is twelve times more effective". It is: in a scenario of analytical equivalence, **the difference in iso-acetic cost may be of that order of magnitude.** Microbiological equivalence must be demonstrated subsequently, but the economic magnitude justifies conducting the trial.

From Iso-acetic Pricing to Real Preservation Cost

The iso-acetic dose is an excellent comparative tool. It is not the final result. Two systems with the same nominal load of acetic acid may exhibit different microbiological behaviours for five fundamental reasons.

pH and Undissociated Fraction

The relationship between CH_3COOH and CH_3COO^- changes as pH is modified. The undissociated form is the microbiologically active one.

Buffering Capacity of the Food

Proteins, minerals, and other constituents may reduce or modify the pH shift produced by the incorporation of the acid.

Physiology of the Micro-organism

Listeria, *Salmonella*, *E. coli*, lactic acid bacteria, yeasts, and moulds exhibit different responses. Even strains within the same species show variability.

Storage Temperature

Porto-Fett et al. demonstrated that the efficacy of buffered vinegars in mortadella was strongly influenced by temperature (4 vs. 12 °C) and the concentration used.

pH and fraction
CH_3COOH/CH_3COO^- equilibrium and active form

Buffering capacity
Proteins and minerals buffer changes

Microbial physiology
Different response between species and strains

Temperature
Storage conditions influence efficacy

CHAPTER 8 · NEW ECONOMIC METRIC

A New Economic Unit: the Cost of Functional Microbiological Efficacy

CFME: Cost of Functional Microbiological Efficacy

$$CFME = \frac{\text{cost of treatment per tonne}}{\text{microbiological result achieved}}$$

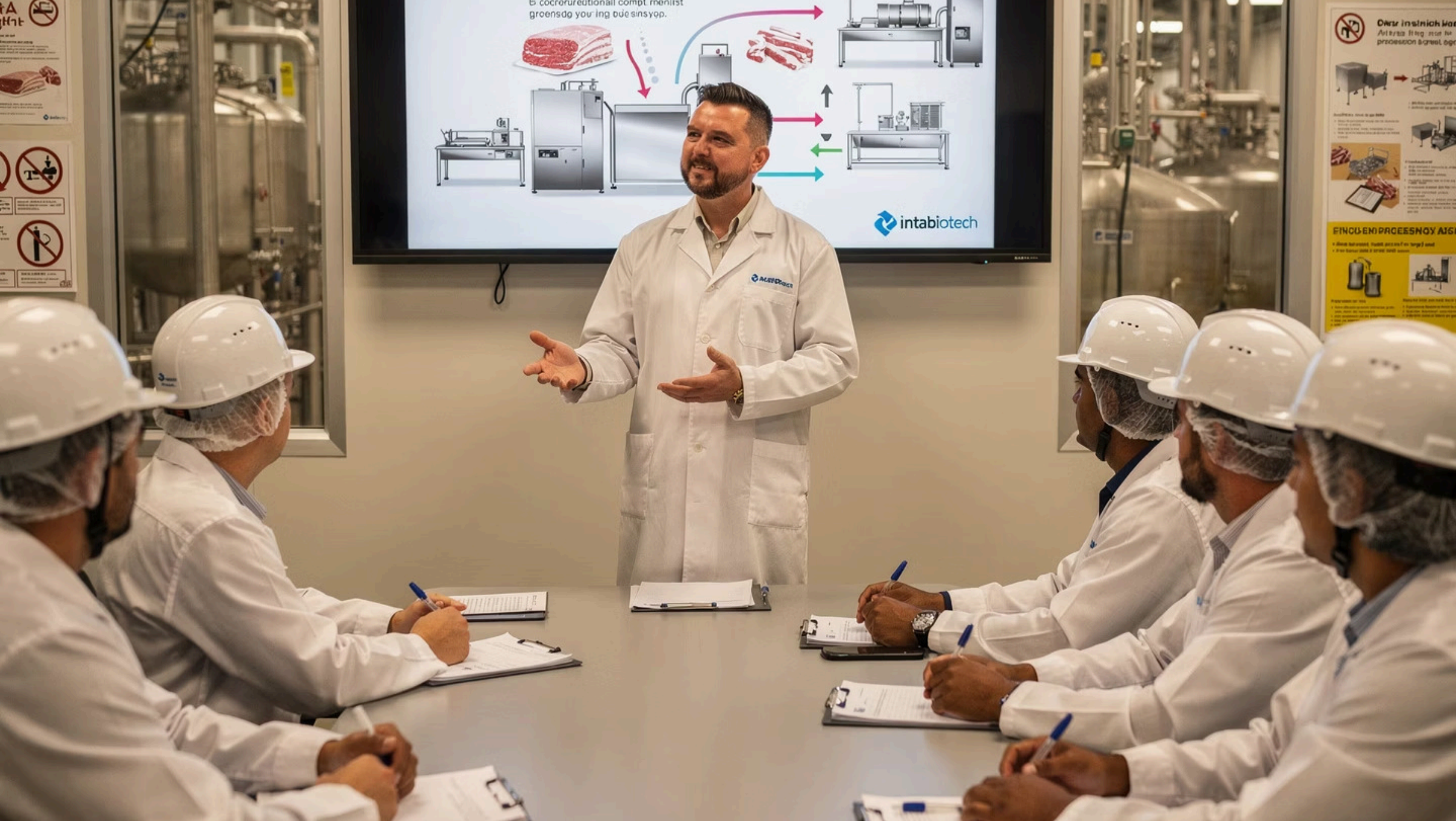
It may be expressed as:

- £/t per logarithmic unit of proliferation prevented
- £/t per additional day of validated commercial shelf life

The appropriate metric must relate the cost of treatment to the result obtained. Selection is not automatic. A system that achieves 40 days of shelf life at 80 €/t may be correct for export. A system of 35 days at 15 €/t may be perfectly sufficient for local distribution.

The answers belong simultaneously to **microbiology, logistics, marketing, and finance**. In certain cases, the more expensive product will be the correct solution. In others, the industry may be paying for a function it does not need.

The true commercial proposition of ACETIPRO™ should be: "Let us determine what minimum dose your food product genuinely requires to meet its objective, and calculate how much it costs to achieve it."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CHAPTER 9 · LIQUID FORMAT

The liquid format: an advantage when the factory requires a liquid

When does powder make sense?

The powdered product is particularly useful in dry premixes, spice blends, dehydrated formulations, and plants with automatic solid micro-ingredient systems. It may offer logistical advantages on certain routes and facilitate multi-component functional preparations.

The key question

Numerous factories procure a powdered system in order to incorporate it into a brine or aqueous phase. The operation may require: receipt, storage, weighing, dispersion, dissolution, and incorporation into the process. When the immediate destination of the powder is water, a legitimate question arises: **what technological value does the powdered state bring to the user's specific process?**

Operational advantages of ACETIPRO™ Liquid

- Direct incorporation into preparation tanks and brines
- Gravimetric or volumetric dosing without prior reconstitution
- Compatible with industrial pumping systems
- Elimination of dispersion and dissolution operations
- No dust generation or risk of caking

The advantage is not microbiological. It is a process engineering advantage. In modern industry, eliminating an unnecessary operation can hold as much value as improving an ingredient.

CHAPTER 10–11 · HIDDEN COST AND METROLOGY

The hidden cost of the liquid–powder–liquid cycle and the importance of density

When does it make sense to dry a liquid only to add water again?

Drying a liquid-origin system can be useful when the end user genuinely requires a solid. However, when a user purchases a dry product and immediately dissolves it in water, the rationality of the operation must be analysed across the full value chain.

In that scenario, **energy and technology** have been used to remove a liquid phase and create a powder that is subsequently returned to an aqueous phase. Furthermore, if the acetic concentration of the powder is low, the industry may be incorporating **several times more mass** of commercial product to achieve a comparable acetic load.

Density matters: one litre ≠ one kilogram

The high concentration of ACETIPRO™ makes it essential to pay close attention to the metrology of dosing. A formulation developed in g/kg must not be transferred directly to L/t without knowing the density of the product.

The technological recommendation should preferably be expressed in:

Primary reference

kg of ACETIPRO™ per tonne of food

Volumetric conversion

L/t = kg/t ÷ density (specified at a defined temperature)

⚠ A concentrated technology demands a proportionally rigorous control of dosing.

CHAPTER 13 · SEASONING VS. FORMULATING

ACETIPRO™ versus conventional vinegar: the difference between seasoning and formulating

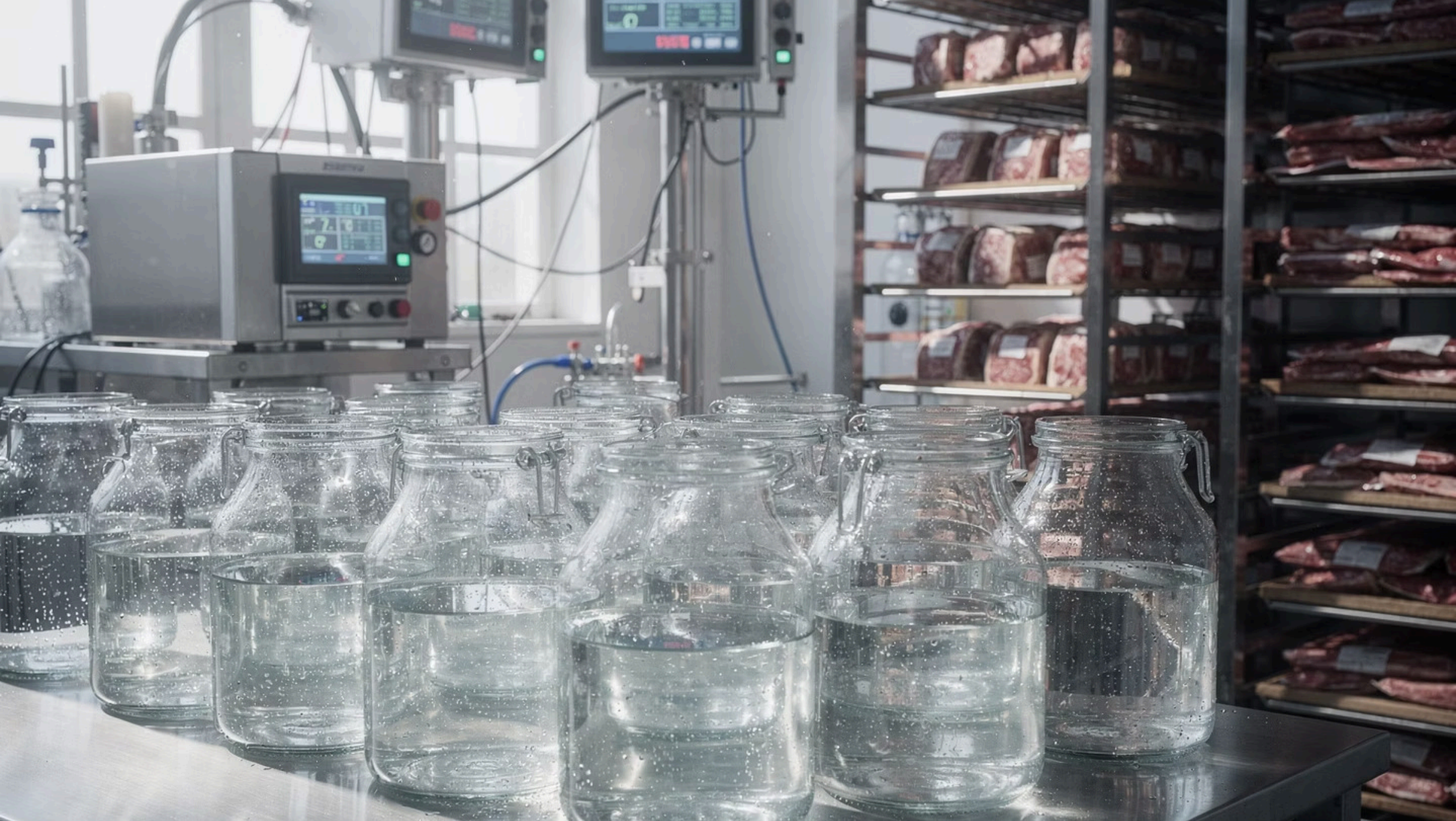
Sensory objective → conventional vinegar

When a characteristic vinegar note is sought, origin, raw material, fermentation, aroma, acidity, and sensory persistence must all be selected accordingly. In that scenario, ACETIPRO™ may not be the appropriate tool.

Technological objective → ACETIPRO™ Liquid

When the objective is to deliver an acetic load, modify the microbiological environment, or integrate a shelf-life barrier, the relevant parameters are: acetic acid content, AAE, pH, dose, microbiological response, effect on the matrix, and functional cost.

Conventional vinegar inevitably combines its acetic load with the product's own sensory identity. Buffered vinegar modifies this relationship. Its higher pH and the presence of acetates allow functional doses to be explored in matrices where intense acidification could prove technologically or sensorially problematic. **ACETIPRO™ belongs to the sphere of industrial formulation, not seasoning.**



CHAPTER 14–15 · MICROBIOLOGICAL EVIDENCE

Listeria monocytogenes and Hurdle Technology

L. monocytogenes: Reference Model in Refrigerated RTE Products

Its ability to grow under certain refrigeration conditions and the severity of listeriosis in vulnerable populations make controlling its growth a priority objective.

- **Porto-Fett et al. (2018):** notable control in mortadella with liquid and dry buffered vinegar at 4 °C; at 1.0–1.5 % it was particularly favourable during extended storage.
- **Badvela et al. (2016):** various concentrations of dry buffered vinegar controlled growth for 12 weeks in reduced-sodium cooked turkey at 4 °C.
- **Heir et al. (2019):** 1 % buffered vinegar fermentate completely inhibited growth in cold-smoked salmon over 29 days; the control increased by ~3 log.

Listeriostatic ≠ listericidal. The objective in refrigerated RTE products is typically to prevent a limited initial contamination from developing into a significantly larger population over the product's commercial shelf life.

Hurdle Technology: The Right Strategy

ACETIPRO™ sits within the *hurdle technology* philosophy, that is, combining different sublethal pressures to achieve a globally restrictive environment.

Cold Chain

Reduces growth rate

Water Activity

Adds osmotic stress

Modified Atmosphere

Conditions microbial groups

Acetic–Acetate System

Additional pressure on cellular homeostasis

CHAPTER 16 · MEAT PREPARATIONS

Meat Preparations: Concentration, Direct Incorporation and Cost

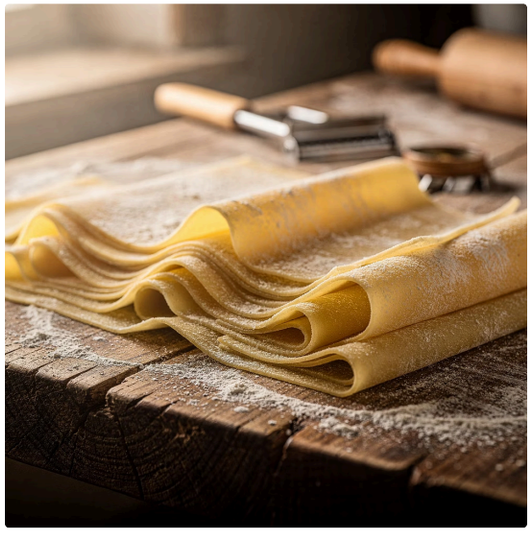
Meat preparations represent one of the areas of greatest industrial interest for a high-concentration liquid acetic system. The presence of aqueous phases, brines, or marinades facilitates the direct incorporation of ACETIPRO™ without reconstitution.

The study of ACETIPRO™ in a burger or meat preparation should not be limited to microbiological counts. It must integrate a **comprehensive multidisciplinary profile**:

- Initial pH and its evolution during storage
- Water activity (aw)
- Microbial counts (aerobes, LAB, Enterobacteriaceae)
- Instrumental colour (CIE L*a*b*)
- Exudate, drip loss, and cooking losses
- Texture and lipid oxidation where applicable
- Sensory evaluation

⚠ **Key legal precaution:** Regulation (EU) 2023/2086 introduced E 267 in category 08.2, limited to pre-packaged preparations of fresh minced meat and meat preparations to which ingredients other than additives or salt have been added. The distinction between a 'meat preparation' and a 'meat product' is not merely semantic: it may determine the legality of the application.

Fresh pasta, refrigerated gnocchi and mozzarella: specific applications



Fresh pasta and gnocchi

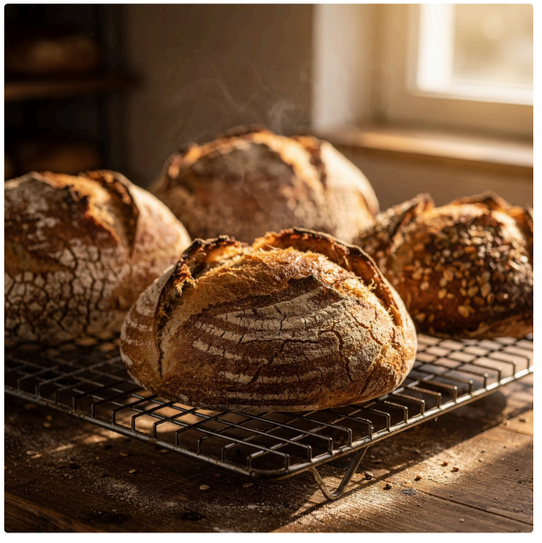
Regulation (EU) 2023/2086 introduced express authorisations for E 267 in fresh pasta, pre-cooked fresh pasta and fresh refrigerated potato gnocchi. The presence of an aqueous phase facilitates direct incorporation during the kneading process. The challenge is to identify the **minimum effective dose** without altering rheological or sensory properties.

Mozzarella and whey cheese

A technologically complex system: the structure depends on the protein network, moisture content, minerals, pH and storage conditions. The study must include surface and central pH, brine, moisture, syneresis, texture, microbiological evolution and sensory analysis. **A microbiologically stable but technologically defective product does not constitute a success.**

The buffering capacity of the system allows the study of acetic acid administration under pH conditions different from those obtained with conventional vinegar, reducing the risk of adverse effects on texture.

Bakery, preserved vegetables, and legal admissibility by category



1

Bakery

The primary spoilage concern is associated with moulds. Evidence against bacteria cannot be extrapolated directly. ACETIPRO™ must be validated through real shelf-life studies using representative isolates of the industrial problem. The correct commercial question: how much does each additional day of shelf life cost?

2

Preserved fruits and vegetables

E 267 has a specific entry in this category. **Unequivocal warning:** ACETIPRO™ does not replace the thermal validation of a preserve, nor does it render a low-acid food stable at ambient temperature. Food technology fails when a valid tool is presented as a universal substitute.

3

Mandatory legal verification by market

European authorisation cannot be automatically transferred to the USA, Latin America, Asia, the Middle East, or the United Kingdom. Each market has its own classification. ACETIPRO™ constitutes a **platform for the administration of the acetic system** with broad potential; its application must be validated according to the matrix, the technological purpose, and the legislation of the target market.

CHAPTERS 22–25 · STRATEGIC POSITIONING

Clean label, organic production, sodium and the definitive comparative trial

Clean label: an honest narrative

The term *clean label* is not a harmonised legal category. E 267 is a food additive and must be declared as such: **preservative: buffered vinegar** or **preservative: E 267**. ACETIPRO™ has a robust narrative without needing to claim "no additives": fermentative origin, acetic system concentrated at 18–20%, lower product mass, direct wet incorporation.

Organic production: ACETIPRO™ Organic

Implementing Regulation (EU) 2025/973 incorporated E 267 among the substances permitted for organic production, on the condition that raw materials are sourced from organic production. This opens a strategically significant line for INTABIOTECH, but the condition must be built documentally: origin, traceability, certificates and mass balance.

Sodium and potassium: beyond acetic acid

A rigorous comparison must also analyse the **mineral contribution**. In foods with sodium reduction targets, a product of lower acetic concentration that needs to be incorporated in greater quantities also increases the contribution of all its components. The complete functional profile must include:

- kg of acetic acid administered per tonne
- kg of AAE per tonne
- kg of sodium and potassium per tonne
- Total incorporated solids
- Total treatment cost

A commercial dry product declares 25,000 mg of Na/100 g (25%). When incorporated at a higher dose to achieve the same acetic load, the sodium contribution increases proportionally.

CHAPTERS 26–29 · COMMERCIAL POSITIONING

From selling preservatives to identifying money losses

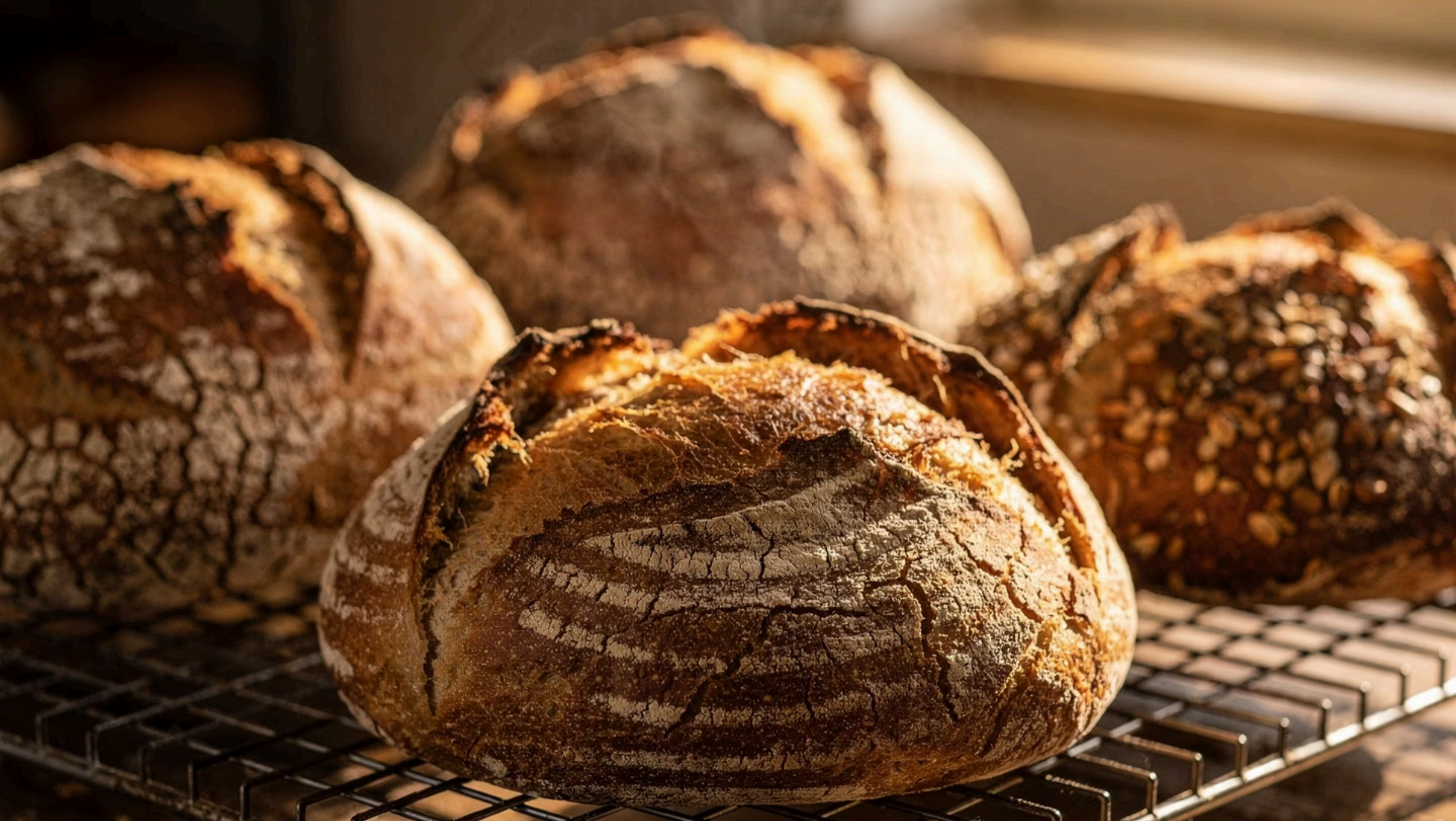
The costs of preservation are considerably greater than the ingredient invoice. **The true cost includes:** operator time, solution preparation, tank occupation, weighing errors, dosing deviations, rejected product, irregular shelf life, returns, and food destruction.

The most effective commercial innovation does not consist of claiming that an ingredient is extraordinary. It consists of **identifying a money loss that the customer has not yet quantified**.

What ACETIPRO™ must not promise

- It does not sterilise a food product
- It does not replace GMP or the HACCP plan
- It does not correct microbiologically out-of-control raw materials
- It does not compensate for a deficient cold chain
- It does not guarantee universal inhibition of *L. monocytogenes* or *Salmonella*
- It is not indiscriminately authorised in every food product

The true competitor of ACETIPRO™ is **formulation inefficiency**. Its natural market is wherever a gap exists between what the industry pays and the function it actually receives.



CHAPTER 30 · CONCLUSIONS

Conclusions: design the acetic load, not simply add vinegar

1 Consolidated scientific foundation

The acetic system acts through the concentration of undissociated acid, anion accumulation, intracellular stress, and systemic effects. pH is a necessary but insufficient variable for characterising the microbiological barrier.

2 Analytical difference with industrial consequences

The free acetic acid content of ACETIPRO™ Liquid (18–20%) versus references at 4–7% implies a nominal ratio of 2.6–5 to 1. For the same nominal acetic load, the commercial mass of ACETIPRO™ required may be between 3.6 and 4 times less than that of a benchmark at 5%.

3 The correct unit of comparison

It is not the €/kg of buffered vinegar. It is the **cost per tonne of food to achieve the required microbiological, sensory, and shelf-life objective**. From this perspective, ACETIPRO™ Liquid presents a particularly competitive position.

4 The technology requires no propaganda when the data are sufficiently clear

ACETIPRO™ must be measured, compared, subjected to challenge tests, and evaluated sensorially. It does not need the industry to believe a promise. It needs the industry to make a comparison.

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CONTACT

Get in Touch: INTABIOTECH Commercial Contact

INTABIOTECH, S.L. is a company specialising in R&D, formulation, and supply of functional ingredients and biotechnological solutions for the food, feed, and nutritional supplementation industry. Our commercial and technical team is at your disposal to analyse your requirements, request a quotation, or explore ordering options.

General Contact Information

Mobile: +34 613 812 425

Telephone: +34 881 092 720

Email: **intabiotech@intabiotech.com**

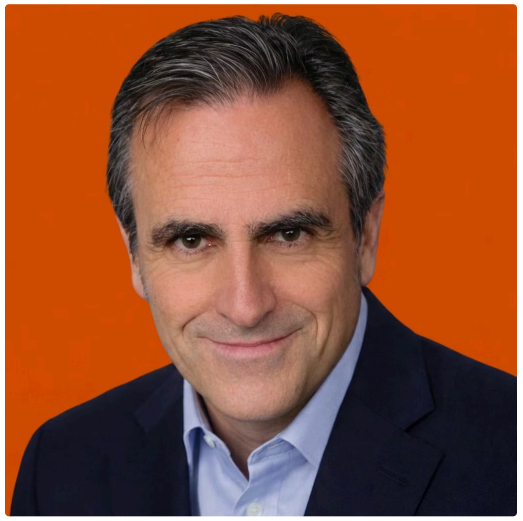
Web: **www.intabiotech.com**

Addresses

Registered and fiscal address: Botiguers, 3, 1ª Planta, Parque Empresarial Táctica, 46980, Paterna, Valencia, España

Industrial address: Avda. Ferreiros, 143, Polígono Industrial Río Do Pozo, 15578, Narón, A Coruña, España

Commercial Team



Álvaro Robles

CCO (Chief Circulation Officer)

+34 609 825 416

a.robles@intabiotech.com

José Ramón Castells

Commercial Manager

+34 674 001 716

jr.ndpharma@europe.com

Sue Rodríguez

Customer Relations & SPM

+34 604 068 683

sr.ndpharma@europe.com

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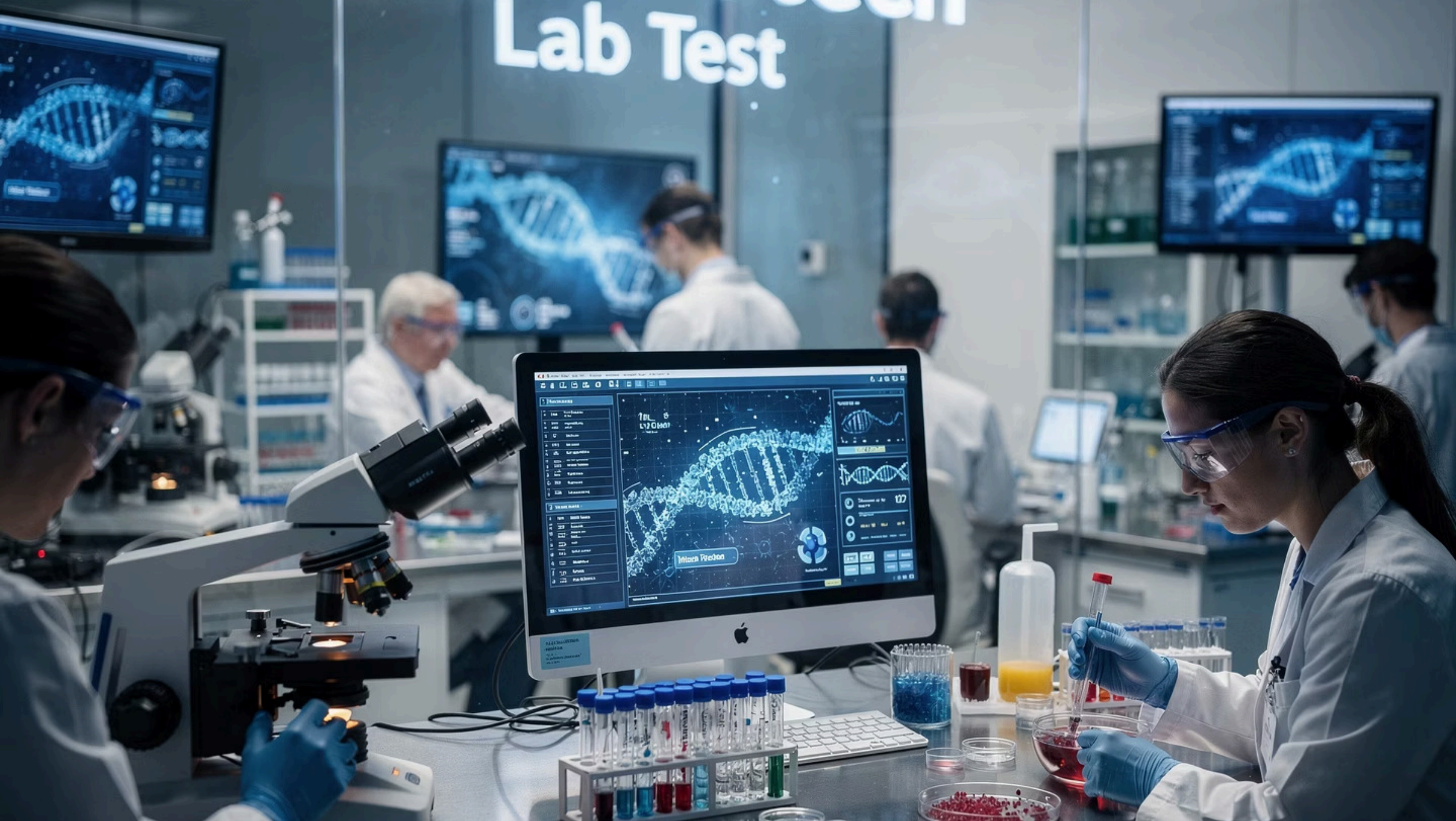
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