

# PROBIOTICS ENCAPSULATION: DRYING PROCESS EFFICIENCY

## CASE STUDY

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Probiotics are living microorganisms with numerous health benefits. To immobilize them and improve their viability over time, encapsulation is a solution with growing interest. For this purpose, three drying processes were studied: **freeze drying (FD)**; **spray drying (SD)**; and an innovative technology — **electrostatic drying (ESD)**. The formulation was also a key parameter that had to be considered. Moreover, to ensure that the process was scalable, drying was also conducted on large-scale equipment.

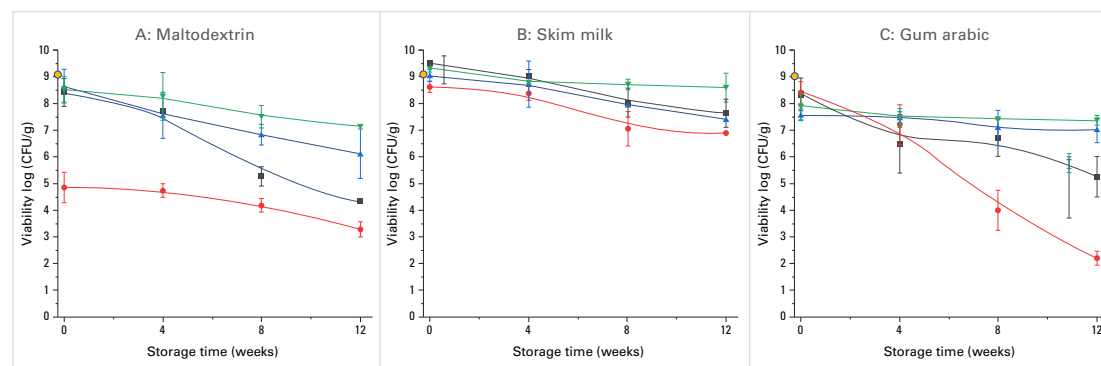
### EXAMPLE: *LACTOBACILLUS RHAMNOSUS* LGG

Three carriers (maltodextrin, skim milk and gum arabic) were tested with three different processes: freeze drying; spray drying; and electrostatic drying at laboratory scale.

Processes	Parameters	Details
Freeze Drying	-30 – 50°C	The feedstocks were prepared at 30% solids content.
Spray Drying	Inlet Temperature: 142 – 170°C	
Electrostatic Drying	Inlet Temperature: 80°C	

### STABILITY & PERFORMANCE ANALYSIS

Influence of the carrier at laboratory scale for the three drying techniques.<sup>1</sup>



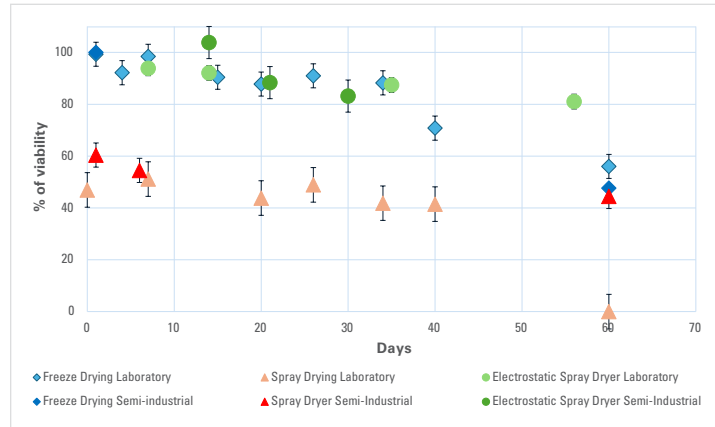
Viability of LGG-encapsulated microparticles (A: Maltodextrin; B: Skim milk; C: Gum arabic) using three drying processes (SD ● ; ESD at 3kV ▲ ; ESD at 12kV ▼ ; FD ■ ) over storage period in weeks with LGG concentration before drying (●).

<sup>1</sup> P. Jayaprakash, C. Gaiani, J.-M. Edoth, E. Beaupeux, F. Borges, E. Beaupeux, A. Maudhuit, et S. Desobry, *Comparison of Electrostatic Spray Drying, Spray Drying, and Freeze Drying for Lactocaseibacillus rhamnosus GG Dehydration*, *J. Foods*, vol. 12, p. 3117, 2023, doi: 10.3390/foods12163117

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It was observed that the carrier had an impact on the stability of the probiotics, post drying. In this study, the most efficient carrier was the skim milk with the multi-component compounds that it is constituted of: fat, protein, and carbohydrates. The ESD technology proved to be a comparative alternative to FD with equivalent or higher stability of LGG for all carriers used. The high temperature SD process did not seem optimal for these sensitive bio products. Scale-up between laboratory and semi-industrial scale was conducted on the three drying technologies and the stability of obtained LGG powder is presented in the chart below:



Comparison of the stability of LGG at room temperature for the three technologies at different scales.

The results demonstrate that stability followed roughly the same trend regardless of the scale of the machine for all three technologies.

High viability (close to 100%) was obtained for FD and ESD just after drying and remained stable for one month. It decreased by half or even completely dropped to zero for SD after two months. Overall, the stability of LGG powder obtained by ESD was higher than powder produced by FD with a gap of 20% and both were higher than SD with a gap of 40%.<sup>2</sup>

For the scale up, formulation based on maltodextrin was used. The results are as follows:

	Freeze Drying	Spray Drying	ESD Model 004	ESD Model 032
Powder recovery (%)	≈ 99	46 – 82	89 – 91	≈ 99
Loss after drying (log)	0 – 0.82	3.6 – 3.9	0 – 0.55	N/A

ESD showed high powder recovery (close to 100%) and a minimal loss of viability comparable to FD. ESD is a continuous process at moderate temperatures which represents an alternative to FD by saving process time and energy.<sup>3</sup>

## CONCLUSION

Powder produced by ESD at laboratory scale presents better LGG stability efficiency for the three carriers tested. The LGG powder stability for the three drying processes are similar for both scales: laboratory and semi-industrial. The capability of ESD to work at lower temperatures allows to preserve the viability of the microencapsulated LGG compared to SD. Working continuously with a high yield at industrial scale, ESD aligns with the desire for continuous production while reducing energy consumption.

## HIGHLIGHTS

### High Stability

ESD shows slightly higher stability over time than FD at laboratory and industrial scales.

### Operational Advantages

Because ESD is a continuous process, it provides substantial time savings during production.

### Scalable Process

The transition to industrial levels was performed while maintaining consistent bacteria viability and stability.

### Formulation Optimization

Selecting the correct carrier is essential for protecting the integrity of the bioactive ingredients.

<sup>2</sup> J-M. Etorh et al, *Electrostatic spray dryer: A new technology to immobilize probiotics* [poster]. Annual NWGD Symposium, Wageningen, Netherlands. 2022

<sup>3</sup> J. Oxley, C. Castilla-Guiterrez, S. Collazos, C. Garza, E. Garza, K. Lange, M. Mamori and A. Zwiener, *Comparison of energy consumption and probiotic stability with pilot scale drying processes*, LWT, Vol 211, p 116937, 2024, doi: 10.1016/j.lwt.2024.116937

