

Beyond Milk: Designing the Dairy Biorefinery of the Future

The dairy sector is entering a new phase of development. Milk can no longer be viewed solely as a raw material for traditional dairy products. It is a complex biological matrix made up of proteins, fats, carbohydrates, minerals and bioactive components that can be progressively separated, purified and put to use.

This shift calls for dairy plants to be reimagined as milk biorefineries, where process engineering makes it possible to obtain products and ingredients with very different nutritional, functional and economic roles from the same raw material.

Inalpi's industrial experience provides a concrete example of this transformation. In the second half of 2027, its Moretta plant expects to reach a processing capacity of around 1,000 tonnes of milk per day. Investments made in recent years, together with those currently under way, are gradually transforming a production model focused mainly on traditional dairy products into an integrated platform for fractionating and making use of milk's various components.

Membrane separation, concentration, purification and drying technologies make it possible to produce high-protein milk protein concentrates and isolates (MPC and MPI) alongside conventional milk powders. They also create opportunities to selectively recover fractions present in much smaller quantities but with significantly greater potential value.

Lactoferrin is a particularly clear example. Although present in milk at extremely low concentrations, it is of considerable scientific, nutritional and economic interest. Its recovery illustrates a fundamental principle of the biorefinery: extracting one component need not be the end of the process. It can be the first step in a sequence that creates further value from the same raw material.

Milk can therefore be seen as the starting point for a cascade of processes: recovering bioactive components such as lactoferrin; separating and concentrating proteins; making use of the lipid fraction and milk fat globule membrane (MFGM) components; recovering specific protein and peptide fractions; and, finally, processing the permeates.

In this approach, streams traditionally considered secondary take on new significance. Permeate, which consists mainly of lactose and minerals, can become a feedstock for further separation, conversion and recovery processes. The long-term goal is to progressively reduce the share of material with low economic value, moving towards a system in which every milk fraction is directed to its most appropriate use, both technologically and economically.

The same structure can also create a direct link between advanced ingredients and consumer products. Some of the fractions obtained through biorefining can form the basis for new foods and nutritional solutions, carrying part of the value created through fractionation into the final product.

The challenge, then, is to design an interconnected industrial system capable of maximising the value obtained from every litre of milk. Achieving this requires chemical and process engineering to work together with food science, biotechnology, nutritional research, genetics, analytical technologies, and advanced control and data management systems.

The dairy biorefinery could thus offer a new model for competitiveness and sustainability in European industry: creating more value from the same quantity of raw material, using resources more efficiently, reducing low-value streams, and developing new applications in ingredients, advanced nutrition and bioactive components.

The future of the dairy industry may depend less on processing more milk than on understanding it, separating it and making better use of every part of it.