

Solutions for plant-based protein manufacturing



Plant-based proteins

We are all aware that our diets affect our health and wellbeing. Consumers are increasingly seeking more wholesome foods and beverages that contain natural ingredients.

High quality plant-derived proteins are now commonly being used to replace their animal-sourced counterparts, and are frequently found in a diverse range of everyday foodstuffs, as well as in vegan/vegetarian products, sports and slimming foods, clinical nutrition products and infant formulas.

Beyond providing essential amino acids, plant-based proteins can be used as functional ingredients to add texture and/or optimize the viscosity, emulsification, stability, foaming or fat-binding properties of a wide range of foodstuffs.

Our expertise

Manufacturers need to be confident that they can produce plant-based proteins that meet customer demands for product purity and functionality, at the optimum yield. Organoleptic and nutritional properties are critical, as are powder characteristics such as particle size, density, solubility and dispersibility.

The food industry in addition faces increasing demands with respect to cost-saving, water and energy use, and other environmental sustainability goals. These, coupled with the need to meet the most stringent microbiological safety requirements, have become important drivers for technology improvement.

To succeed in these fast-moving, highly competitive global markets, producers also need the flexibility to develop new products and processes.

GEA's world-leading industry know-how and technological expertise enable us to provide the optimum solution for each customer's requirements.



Plant-based protein manufacturing solutions

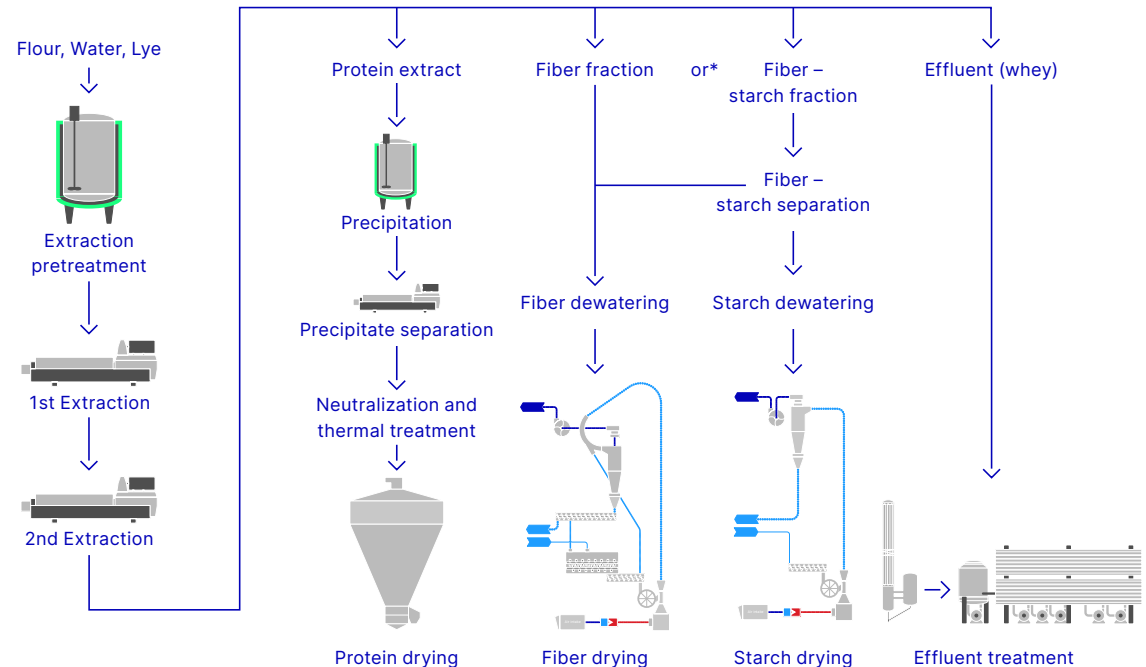
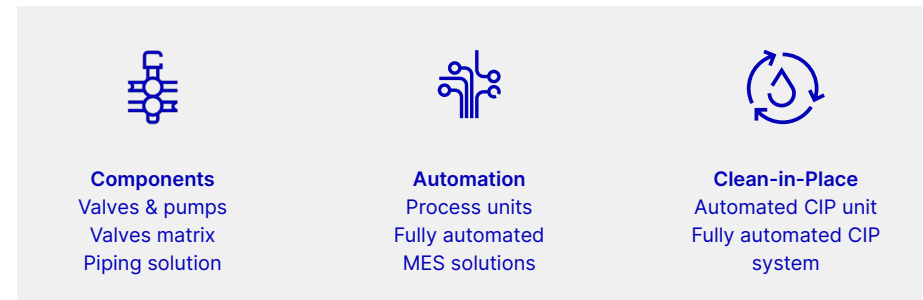
GEA has developed a comprehensive range of technologies, equipment and know-how to configure and install fully integrated manufacturing lines for plant-based proteins.

We work with our customers to tailor optimized solutions that take into account the key requirements of protein type, capacity and level of automation. Our expertise spans the complete process, from raw materials preparation, protein extraction, isolation and purification, to protein, starch and fiber drying and effluent treatment.

GEA experts will partner with you at every stage of plant design, construction and engineering, starting at inception, design and equipment purchase, through to installation, commissioning and hand-over.

GEA process design and plant integration

We can supply preconfigured, standalone equipment and technologies or tailor, deliver and install completely integrated processing lines that match your plant infrastructure. Whatever the scale, our technologies are designed to handle a variety of different products and processes, giving you the flexibility to stay ahead of the competition.



*depending on the raw material

Hygienic design and product safety

Backed by more than 50 years of hygienic and aseptic process design experience, GEA designs and configures state-of-the-art cleaning solutions to ensure optimum hygiene and microbiological safety for every line. GEA customers benefit from the highest levels of product safety, reduced downtime, and optimized use of water, power and cleaning agents.

Training and support

GEA offers training and support, so that our customers can be confident that all their equipment and process lines offer optimum throughput and reliability for the entire lifecycle of the plant.

Project management

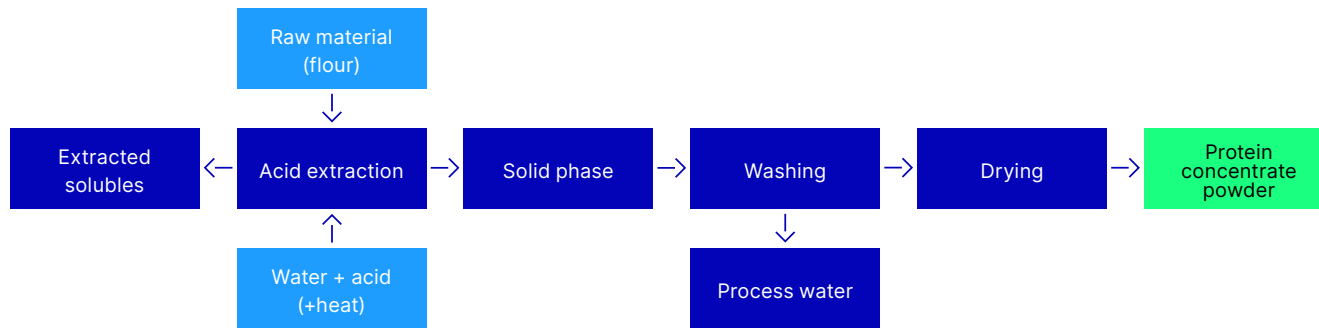
GEA makes sure that no detail is overlooked, and that every deliverable is achieved on time.

- All GEA customers benefit from our world-renowned project management expertise. We undertake all aspects of project execution, from the earliest stages of design and layout through to equipment delivery and installation, including international contract management, commissioning and start up.
- A dedicated team will liaise with third-party suppliers and provide comprehensive after-sales support and training.

Partner with GEA and you have the security of expert support from day one, with options for flexible service, maintenance and upgrade packages.



Protein manufacturing



Example of protein concentrate process

A plant-based protein manufacturing process essentially comprises protein extraction, purification, and drying, whether that process is used to make a concentrate or an isolate. The procedure also includes further processing of by-products, such as fibers, starch and soluble components in the water effluent streams. Clean-in-Place (CIP) and automation complete the installation to ensure reliable and hygienic production of plant-based protein ingredients for food and feed applications.

GEA has the knowledge and expertise to identify and supply the most appropriate process solutions for all raw materials, including oil-rich crops such as soy, and starch-rich crops such as peas and potatoes.

The starting material for protein extraction is often a flour — obtained from beans or seeds by dehulling, grinding and

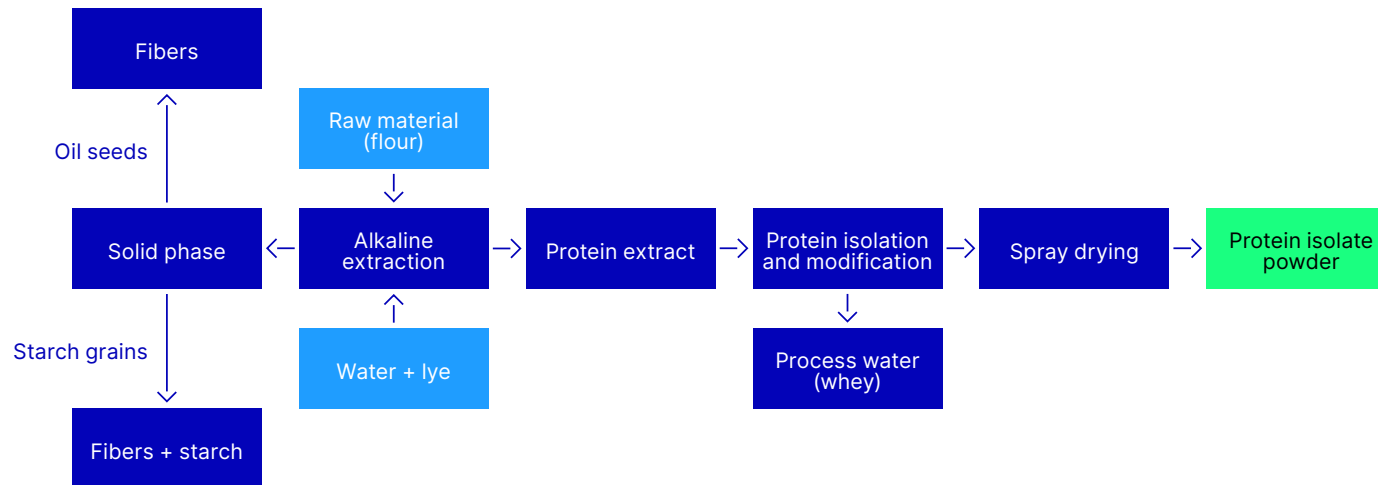
sieving — which is then mixed with water in a predefined ratio to balance cost-effectiveness with protein purity and yield. The pH of the mixture is subsequently adjusted to acid or alkaline, dependent upon the final product that is being manufactured.

Protein concentrate extraction

Liquid extraction of a protein concentrate starts with protein coagulation and separation of the precipitated proteins and insoluble fibers using a GEA decanter. Coagulation occurs at a pH around the isoelectric point or at elevated temperatures. The collected solid phase is then dried in either a GEA ring dryer or spray dryer, depending on the type of product and the final use of the protein concentrate. This process results in vegetable concentrates with a protein level of at least 50%.



Protein isolate extraction



Example of protein isolate process

In alkaline extraction conditions, the protein fraction dissolves predominantly in the aqueous extract; this is the first step in making a vegetable isolate with a protein level of at least 80%.

To separate the aqueous extract from solids, GEA engineers will preferentially configure two decanter stages operating in counter-current extraction mode. This configuration minimizes water consumption and optimizes product yield and quality. The protein-rich aqueous extract can then be further purified and concentrated.

The composition of the solid discharge from the decanters will depend on the raw material. When processing oilseeds such as soybeans and rapeseed, the solid fraction primarily

comprises insoluble fibers. The solid phase derived from starch-containing raw materials such as peas, beans and lentils will contain both insoluble fibers and starch. In this case further refining of both fractions should be considered.

Protein precipitation and purification

The water phase obtained from alkaline extraction contains most of the dissolved proteins; these are subsequently precipitated out of the aqueous phase and separated in a decanter. The water phase from the decanter — the whey fraction — mainly consists of salts and soluble carbohydrates.

The solid phase, which remains in the decanter, is known as the protein curd. This undergoes dilution, pH adjustment and thermal treatment before the proteins isolated from the curd

are spray dried into the protein isolate powder. Carrying out additional washing in a clarifier centrifuge creates an even higher purity of protein isolate.

Thermal treatment acts as a pasteurization step, and is also key to determining the final functional properties of the product. Additional enzymatic modification or conditioning steps can be included to alter the functional characteristics of the protein, including solubility, gelation, water binding and emulsification.

Specific membrane separation steps can be introduced to selectively isolate certain protein fractions.

Separation



GEA centrifugal separator with integrated direct drive



GEA centrifugal separator with flat-belt drive



GEA decanter centrifuge

GEA offers a range of efficient, versatile decanters and centrifuges for the separation of protein concentrates and isolates. All of our equipment is available to test and trial at our state-of-the-art technology centers.

Features of GEA decanters and centrifuges:

- High separation efficiency for extremely pure proteins and optimal protein yield
- Sophisticated and innovative drive systems enable reduced energy consumption
- Hygienic design with optional CIP meets all food-grade processing requirements.

Our separation know-how and extensive equipment portfolio means we can always provide the right decanter and centrifuge to meet the specific requirements for your application.

Protein drying

The protein-rich fraction derived from the isolation and purification steps is diluted to the required concentration and viscosity, prior to atomization in a spray dryer. GEA offers a wide range of spray dryers that can be configured to accommodate a broad spectrum of powder properties.

The choice of dryer will depend upon the level of protein hydrolysis and desired final powder properties, such as particle size and density, as well as the required solubility and dispersion properties.

The FSD® from GEA is a multi-stage unit that combines spray drying and fluid bed technology in one plant. This solution is ideal for customers who need a high level of flexibility to make powders with different levels of agglomeration, lecithination and particle size. The FSD® generates uniform, coarse, free-flowing and dustless particles and powders with excellent dispersibility.

GEA can also configure a TALL FORM DRYER™ with nozzle atomizers to produce small particles and agglomerates with particle sizes of 50–150 µm. Alternatively, a conventional

single-stage spray dryer with a VIBRO-FLUIDIZER® external fluidized bed is available to produce particles larger than 100 µm.

All GEA technologies can be evaluated in our dedicated technology centers to assess specific product requirements. GEA experts can work with each client to configure and optimize a spray drying solution that matches plant design and capacity for each product.

Key features of GEA spray dryers:

- Controlled drying conditions to maintain solubility, water holding capacity and gelling attributes
- A wide range of powder properties can be accommodated
- Drying and agglomeration can be carried out in a single operation to enable cost-efficient and hygienic processing
- High quality agglomeration and lecithination for excellent dispersibility
- Optimized CIP for fast, effective cleaning and reduced downtime.



GEA FSD® spray dryer

Starch and fiber drying



GEA flash dryer

GEA solid feed dryers allow multiple configurations for rapid drying of products. These dryers are ideally suited to dry powders, cakes, granules, flakes, pastes, gels and slurries.

Starch produced during the process is commonly dried in a flash dryer, whereas feed type ring dryers are ideal for more fibrous animal feed materials.

Both types of dryer can feature a twin paddle mixer, which can act as a buffer hopper, or for back-mixing/feed preparation of the material before it is fed into the dryer air stream. The wet feed is dispersed into the drying air stream via either a cascading screen, a sling or a disintegrator. The type of unit that is chosen will depend on how much milling of the product is desired.

GEA offers a range of flash dryer configurations, from single-pass to P-type ring dryers that feature extended residence times, and which are ideal for heat-sensitive products.

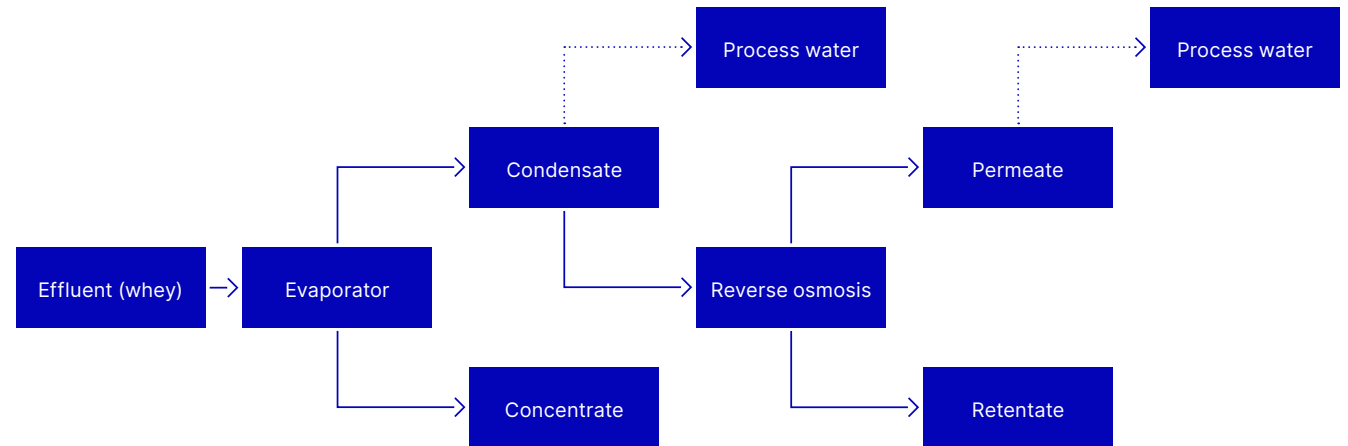
In a flash dryer, wet material is dispersed into a stream of heated air, which conveys it through a drying column. The heat from the air stream dries the material as it is conveyed. Product is separated using cyclones before the drying air is exhausted to the atmosphere.

Incorporating a GEA suction discharge system into the dryer configuration can typically reduce dust emissions to below 20 mg/Nm³.

Our feed type ring dryer has a manifold (or “internal classifier”), which selectively recirculates heavier semi-dried material back to the wet feed point for another pass through the system, while the lighter, drier particles continue on to the product collection system. This reduces the exhaust temperature, increases efficiency and improves product quality.

Even greater thermal efficiency can be achieved by running the dryer in a partial gas recycle (PGR) configuration. The bleed-off gas stream delivers a lower exhaust emission rate and can also be used as an alternative heat source for an evaporator.

Effluent treatment



Example of effluent treatment:

GEA offers efficient, sustainable technologies to recover process water and minimize fresh water consumption. Effluent from the protein isolation process can undergo thermal separation in an evaporator, to produce a concentrate and a clean condensate.

To ensure the best product quality, GEA's falling film evaporator is designed to operate under vacuum and a low temperature difference. The sophisticated liquid distribution system, combined with product recirculation, ensures gentle evaporation. Dependent upon the available energy form and price, the evaporation system may be designed as a multi-effect plant heated by a thermal vapor recompressor

(TVR, steam) or a mechanical vapor recompressor (MVR, electrical energy).

Owing to their low liquid content, GEA's falling film evaporators react quickly to changes in energy supply, vacuum, feed quantities, concentrations, etc. This makes them flexible and easy to operate, and ensures a uniform final concentration. The low liquid content also enables quick start-up and easy changeover from operation to cleaning mode.

Condensate from the evaporator can be further purified in a GEA reverse osmosis (RO) plant to generate a concentrated retentate and a permeate of very high purity, which could be recycled as process water. The RO permeate can also be used as CIP water.

GEA offers the most advanced cross-flow membrane filtration systems, from RO up to microfiltration. A wide range of membrane system configurations and types is available to optimize each separation application.

CIP and Automation

CIP to save time, resources and costs

Microbiological control measures and hygienic process design are critical considerations when processing vegetable proteins. Post production, any remaining product may pose a contamination risk and/or become a source of microbial growth. Process design, heat treatment and CIP solutions all play integral roles in ensuring microbiological safety and minimizing cross-contamination. Optimized CIP also minimizes the use of cleaning agents and water to significantly reduce downtime and lower costs.

Innovative CIP solutions from GEA meet all the required hygiene standards to guarantee product safety. Our effective CIP solutions remove any leftover product from the plant, tank surfaces, heat exchangers, pumps, pipes, etc. We can also design and build systems with SIP (Sterilize-in-Place) functionality for high microbiologic control.

Process automation for reliable, reproducible manufacturing

Every plant has different process automation requirements. GEA offers automation systems and services that range from basic process control to integrated, enterprise-wide networks with an MES (manufacturing execution system).

Our MES solutions are built on extensive industry know-how and allow customers to manage and monitor every stage of their production processes to ensure both optimum use of resources and consistent product quality.



GEA CIP unit

GEA test centers



GEA centers of excellence offer laboratory and pilot plant facilities and a wide range of GEA equipment for customers to try out new recipes and work on process development and validation. Our experts will help you to select and tailor the best technologies for your processes, optimize every process stage, and evaluate new formulations, from early stage product development through to final process refinement.

A test center for centrifugal separation is available in Germany. Evaporation and membrane filtration can be tested in Germany as well as in the USA. Both solid feed drying and spray drying facilities are available in Denmark and the USA.

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