New food ingredients opportunities

The sidestreams of many manufacturing processes contain valuable functional proteins that represent a significant source of untapped revenue. By enabling food-processing companies to isolate these proteins, Upfront Chromatography is opening up new revenue opportunities in food ingredients.

Introduction

Traditional isolation methods have been unable to separate proteins at the required purity and functionality for high-value markets, such as food ingredients. Though, in a number of ingredient industries, filtration methods are used to extract different grades of proteins, often these techniques do not provide sufficient end-product quality with isolated proteins frequently containing traces of chemical compounds such as polyphenols. Alternative separation methods, such as heat coagulation, can denature proteins and thereby destroy their functionality and value. Proteins that are isolated using these methods can only be used for low-value applications, such as animal feed.

The revenue increase generated by shifting from feed to food ingredients is significant. Current feed prices range from 0.5–1.0 US dollars per Kg. However, food ingredient prices are substantially higher. For example, the estimated food ingredient prices for whey protein isolate and potato protein fluctuate in the range of 8–10 US dollars per Kg; for egg powder and caseinate, the range is 6–8 US dollars per Kg; and soy proteins sell on the market for about 3–5 US dollars per Kg. Functional proteins isolated from the sidestreams of crop processing have the potential to replace many of the egg- and milk-derived proteins commonly used as ingredients.

By employing cost-effective, modern separation techniques, Upfront is helping its customers to isolate a wide range of active, functional proteins with a vast range of applications including foaming, emulsifying, solubility, gelation etc.

Solanic case study

Background

In partnership with Solanic, a business unit of the world's largest producer of potato starch and starch derivatives, AVEBE, Upfront has developed an industrial separation process that can isolate more than 1000 tonnes per year of high-value, functional proteins from the sidestream of potato starch production. The purification plant was officially opened on December 5th, 2007, in Gasselternijveen, The Netherlands. The proteins isolated are of sufficient quality and purity for use in the food and healthcare markets, thereby increasing the value of its protein product significantly. The project will be the world's largest industrial protein chromatography installation by far and is projected to reach production of 10,000 tonnes of protein per year in a second phase.

Regulatory and technical services

The technology used to undertake this industrial separation is licensed to Solanic by Upfront. Upfront has developed considerable expertise from working with its industrial partners to develop customised chromatographic separation services across a wide range of industries. It has also built up regulatory experience in the food and healthcare industries, which have been central to attaining the additional value.

Successful implementation of the project followed a full process development service, including feasibility, optimisation and pilot-scale studies, before the main installation was created.

The licence and installation process included the five following tasks:

- Identification of the type of proteins that can be isolated;
- Identification of suitable ligands used as a tool during chromatographic process for efficient capture of specific functional proteins at the required purity;
- Process optimisation in order to perform the specified separation at the required manufacturing capacity;
- Scale-up to industrial installation; and
- Technology transfer and training.

Economic benefits

Through the selection of appropriate ligand chemistry and process optimisation, the Rhobust installation exceeded all agreed objectives with respect to yield, purity and quality within the required production goals, as set by Solanic. Only Rhobust could isolate high-purity, food-grade quality targeted proteins and thereby increase revenue from protein by-products.

The potato proteins that were isolated using Rhobust have a range of unique and functional properties and were nominated for Fi Europe's Most Innovative Food Ingredients Awards at FIE in London, October 2007.

Brief overview of Rhobust

An EBA Process

The Rhobust processing platform is a 'next-generation' Expanded Bed Adsorption (EBA) chromatography system, which has a number of key features that make it particularly suitable to large-scale industrial processes, as indicated in Table A.

The principle of EBA is to allow the chromatography beads to fluidise in the feed stream, which is pumped at low pressure. The expanded bed allows particulate impurities in the feed stream to pass freely and at very high flow rates through the system, without any clogging or

A rhobust next-generation EBA column from Upfront

pressure build-up. As a result, they can be used on crude feed stocks. Expanded beds generate no backpressure from fluid flow resistance in the bed, and the columns can be scaled up to a diameter of 1.5 metres.

Rhobust offers a single-step solution for isolating functional proteins from crude feed streams and this is employed in some of the world's largest chromatography processes. The basic EBA technology has been developed by Upfront so that it enables highly selective product recovery from complex mixtures at high throughput. A number of these key developments are illustrated in Table A.

Robustness

Traditional chromatography processes using packed beds are inherently sensitive to changes in feedstock or fluctuations in flow rate or even temporary problems such as the release of air bubbles into the column. Rhobust has been designed with high-density adsorbents to withstand such changes, which has the result of improving process productivity (shorter cycle times) and conferring a high degree of inertia, towards disturbance of the bed, for an improved system robustness.

The Rhobust adsorbents are exceptionally stable to harsh regeneration under a wide range of cleaning conditions, which enables the column and associated fluid lines to be effectively washed and decontaminated. They have also been designed to withstand high-temperature cleaning with hot caustic solutions, such as 1M NaOH, required for the food and healthcare industry. The adsorbents have also been optimised for low toxicity and very low leakage.

High selectivity

Capture and release of target proteins are critical aspects of the separation process and these must be done without loss of functionality. Mixed-mode ligands are useful when fragile compounds must be isolated in high yields because mild chemical conditions can be used to disrupt binding and recover the purified product. The use of mixed-mode ligand chemistry enables binding of the target molecule, even at high ionic strength, and releases it again by a simple change of pH, which maintains the biological activity of the product. Mixed-mode ligands can be readily implemented in large-scale production facilities and are particularly suitable to industrial applications where the crude, raw material often contains relatively high salt concentrations. These ligands capture the target biomolecules directly from the raw material, thus providing a high degree of selectivity.

FEATURE OF OPTIMISED HARDWARE FOR RHOBUST	PROCESSING BENEFITS
Increased bead density	* Improved robustness of system – less susceptible to changes in process conditions * Increased operational flow rates * Improved process control – enables low bed expansion for washing and elution procedures
No porous plates, screens or meshes hardware designs	* Improved capability to process crude, in unfiltered feedstocks * Improved cleanliness
High fluid velocity cleaning in place – elimination of low flow areas	* Lower risk of contamination issues * Lower risk of batch-batch cross-contamination
Low-pressure operation	* Lower cost of construction materials for large-diameter systems * Can incorporate transparent materials for safe visual inspection of systems * High-temperature cleaning-in-place operations

Table A. Improvements to expanded bed hardware and the processing benefits.

Conclusion

The isolation of high-value food ingredients and other functional proteins from the side-streams of industrial processes offers food processing companies an opportunity to substantially increase their revenues. Upfront is enabling these companies not only to understand the value held within their side streams, but also offering a practical solution that can isolate high-quality functional products.

From consultation and pilot study to final installation, Upfront's engineers and chemists work in partnership with clients to develop their process and optimise recovery, within the confines of the existing manufacturing site.

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