Food & Drink TECHNOLOGY

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From side-stream to revenue stream

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Recovery of high value ingredients turns loss into profit. Morten Olander, Upfront Chromatography explains

Increased competition in food manufacturing is forcing many companies to explore how they can increase revenues and profits by recovering high value proteins from the by-products of their manufacturing processes. The side-streams of many industrial processes often contain high value functional proteins that when isolated can be used for food or healthcare applications. For most companies these proteins represent a potentially valuable source of untapped revenue.

Significant technological developments over recent years have produced an extremely effective technology that can be customised for virtually any high value separation challenge. The technology enables companies to mine their process streams for valuable functional proteins that were previously unobtainable using other classical chromatography or membrane technologies, and is currently licensed to leading manufacturers around the world.

The technology, developed by Upfront Chromatography, opens-up new revenue opportunities for food manufacturers. For example, many companies employ separation technologies that can only isolate low quality proteins suitable for animal feed. Using Upfront's Rhobust technology, they are now able to isolate proteins at the required quality, purity and functionality for food and healthcare markets.

In one project with Solanic, part of the Avebe group, the technology is being used to develop a process that will isolate more than 1,000 tonnes per year of high value functional proteins from the side-stream of potato starch production for use in food ingredient applications and healthcare. The project will be the world's largest industrial protein chromatography installation by far and is intended to reach production of 10,000 tonnes protein per year in a second phase. Other separation methods were unable to provide the necessary protein product quality to be used in food applications. The technology licensed by Upfront has provided a solution to this problem and enabled the transition from feed to food ingredients, thereby increasing the value of the protein product significantly. Successful implementation of the project included offering extensive technical and regulatory support, from identification of suitable adsorbents for capture of specific functional proteins, through to adsorption process optimisation and supply of the customised adsorbent.

Expanded Bed Adsorption

The technology, based on Expanded Bed Adsorption (EBA), has a number of key features that make it particularly suitable to large-scale industrial processes (below). The principle of EBA is to fluidise the chromatography beads 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 pressure building up and can therefore be used on unclarified feed stocks. The EBA process offers a single-step solution which eliminates costly pre-filtration steps of packed-bed implementations, and has the potential to deliver significant cost savings over traditional separation systems.

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.

Increased adsorbent density improves the robustness of the system, to withstand changes in feedstock or fluctuations in flow rate or even temporary problems such as release of air bubbles into the column. Encapsulation of tungsten carbide particles within agarose beads increases the density of adsorbents to about 3 kg/l. This increased density means that higher upward flow rates can be utilised to stabilise the adsorbent in the expanded state. This has the result of improving process productivity (shorter cycle times) and maintaining stable low expansion heights during washing and elution for minimal dilution. But even more importantly the higher mass of the adsorbent bed confers a high degree of inertia towards disturbance of the bed for improved system robustness.

Expanded beds generate no backpressure from fluid flow resistance in the bed and the columns can be scaled to a diameter of 1.5-2.0 metres. The bed height can also be as high as is required for efficient adsorption/desorption. A simple yet robust system has been developed that uses a proprietary rotating fluid distribution arm that allows trouble-free processing of crude feedstocks. Furthermore, because the column operates at low pressure, the

Feature Article

Magic mushrooms

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Product Showcase

Minimum film, maximum benefit

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hardware can easily be made compatible with frequent changes of the temperature from cold room or ambient temperatures to high temperature clean-in-place procedures.

Farmers

The dairy industry continues to be a key area that employs separation technology for isolation of functional proteins from whey, a by-product of milk processing. Upfront provides state-of-the-art processes for isolation of whey proteins and has developed methods to separate a wide range of proteins including Lactoferrin (LF), Lactoperoxidase (LP), Immunoglobulin (IgG), alpha-lactalbumin and beta-lactoglobulin.

Dairy Farmers, one of Australia's largest dairy manufacturers, needed to develop two sanitary processes for the isolation of functional proteins from cheese whey for use in food and healthcare. The first process was designed to isolate LF, LP and a second for IgG. The platform developed can process more than 200,000 litres of cheese whey per day and is the world's largest expanded bed adsorption system. Key features of the system are its operational robustness with crude (unfiltered) feedstocks, excellent process control, direct scalability, high selectivity and use of high temperature cleaning with sodium hydroxide (NaOH).
Three cycles per day of 85,000l of whey is passed through a 1.5 meter diameter column (250l adsorbent) at 900cm/hr. LF is adsorbed to the cation exchanger adsorbent which has a working capacity of between 27-54 g/l depending on the quantity of LF in the whey. After washing with water to remove particulates, lactose and contaminating protein, the product is eluted in mild alkaline solutions. Product yields of between 90-100% are achieved and the purity is represented as a single band on coomassie stained polyacrylamide gel electrophoresis (PAGE). The robustness of the system is demonstrated by high temperature cleaning at the end of the day using 1M NaOH at 60˚C for 1 hour.

A second separation step enables direct capture of IgG using a mixed mode chemical ligand that has selectivity for IgG over all other whey proteins. The combination of selective ligand and robust processing platform is key to the operational efficiency of the process. Depth filtration and other finer pre-filtration unit operations are not required for trouble-free processing, even with large adsorption systems such as the 880l column used for IgG capture.

For this second adsorption system the whey is heated to 50˚C in order to reduce the viscosity of the solution; in this way use flow rates of up to 1500cm/hour without a substantial change in working adsorbent capacity. 26,000l of whey is loaded per cycle at 900cm/hr on the 1.5 meter diameter column (880 litre adsorbent) without significant back pressure.

The adsorbent system has a working capacity of between 10-20 g/l of IgG and yields >90% of the IgG in the whey, producing up to 13kg of IgG per cycle. Seven to eight cycles are run in one day followed by high temperature cleaning with 0.5M NaOH plus detergent. The specially optimised mixed mode ligand elutes the functional IgG with a near-neutral pH solution and the aqueous immunoglobulin solution is concentrated on a membrane and freeze dried.

Conclusion

Isolation of high value food ingredients and other functional proteins from the side-streams of industrial processes offers companies an opportunity to create substantial additional revenue. With a greater understanding of the value of food ingredients and the technology that can isolate high quality functional forms, new opportunities for food and healthcare are now a reality.

The application of this technology ranges across a number of industries and the range of proteins that can be isolated is extremely diverse. Consultation with specialist service providers, with a proven track record of delivering industrial-scale separation, enables companies to understand and extract the additional value held within their manufacturing processes without disrupting existing processes. The technology has unlocked the potential of creating additional revenue, a solution that industries have been requesting for decades. ■