RHOBUST®WHEY REFINERY:

Novel Way for Separation of α -lactalbumin and β -lactoglobulin In Whey



The Rhobust[®] Whey Refinery

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The Rhobust[®] Whey Refinery is a new, unique concept which enables the dairy processor to fractionate whey proteins into specialized, high value added ingredients. This case study will focus on the separation of a-lactalbumin and β -lactoglobulin in whey to achieve two high purity products.

Benefits

- Isolation of proteins directly from unclarified crude whey
- High capacity combined with high flow rate
- Water and chemical recycling
- Fractionation of whey proteins to specialized products
- High purity and high value products

The Challenge

The separation of a β -Lg and a-La to produce a β -Lg depleted a-La product is insufficient when using membrane filtration. Until now the separation of these two proteins has been cost-inefficient when using chromatography and in addition there is a perception in the industry that chromatography is complex, expensive and is a burden to the environment.

Sufficient, cost-efficient and eco-friendly separation of a-La and β -Lg can now be achieved using Upfront's Rhobust[®] Whey Refinery.

Technology

Based on the well-known Expanded Bed Adsorption (EBA) technology, UFC has launched the Rhobust[®] Whey Refinery which enables the dairy processor to extract and process proteins from industrial solutions like whey into high value added ingredients.

The Rhobust[®] Whey Refinery is based on the Rhobust[®] Flex chromatography system



Figure 1: Industrial plant for purification of whey proteins.

and the Fastline[®] adsorbent media for high performance processing. The adsorbent media must feature a higher density than the feed stream in order to obtain an acceptable flow rate during operation, keeping the resin in a stable fluidized state in the column. The density is controlled using an inert, high density core made of an inorganic material, while the polymer phase surrounding the inorganic particles is made from cross-linked agarose. The system provides the processor with a selfcontained system ready to operate on any type of whey without prior pre-treatment.



Figure 2: Adsorbent close-up: High density particles encapsulated into agarose matrix.

A unique process technology

Using the Rhobust[®] EBA One Step process, the crude whey can be treated directly in the chromatographic column, thus avoiding the traditional clarification and pretreatment steps. This is a significant improvement compared with the traditional process technologies.



Figure 3: Traditional process technology (dark blue) vs. Upfront's one step procedure (red) for whey protein purification.

The impurities in the whey will pass unhindered through the chromatography column, together with lactose, minerals, fat globules and the various low molecular weight substances. The resin will absorb the proteins which can then successively be eluted with buffers at different pH values. This basically eliminates the cumbersome pre-treatment of the whey necessary in the more conventional processing. While chromatography usually has been connected with complicated processing, large chemical consumption and excessive water consumption, the Rhobust[®] EBA One Step system eliminates these concerns.

The use of chemicals is minimized due to low concentration of buffer solutions, which are partially recovered by means of conventional membrane processing, and, likewise, the water is reused through the application of advanced water recovery technologies.

From crude whey to high value ingredients

Whey contains a wide range of proteins with exceptional nutritional and functional properties. The content of protein in whey is approximately 5 – 7 gram/litre. The alactalbumin has a concentration in whey of approximately 0.6 gram/litre, - 1.7 depending on the type of whey and the treatment of the milk prior to cheese or casein production. By using the EBA chromatographic technology the alactalbumin can be isolated from whey and converted into a powder.

Simple processing steps

The processing of whey is illustrated in the flow diagram. In the first elution step the β -Lg is removed from the column with a lactate buffer and in the second step the a-La is eluted by means of a mild alkaline solution. The a-La solution has an a-La/ β -Lg ratio of 4 – 6 which makes it ideal for infant formula.



Figure 4: Flow diagram for the separation of α -La and β -Lg in whey.

The eluate is concentrated by ultra-filtration to approximately 20 percent protein, followed by spray drying to form a white, free flowing, a-La enriched WPI, depleted of β -Lg. The water consumption is minimized through buffer reuse, and this also reduces the consumption of chemicals.

As a co-product, the β -Lg eluate can be concentrated and spray-dried. β -Lg is increasingly being used for gelation and emulsification in a wide range of food formulations.



Figure 5: Whey protein powder.

The products

This figure shows the electrophoretic pattern of purification of a-lactalbumin and β -lactoglobulin. The first lane shows the composition of the crude sweet whey. The second lane shows the composition of the flow through, without any proteins except GMP, which can be isolated using Upfront's anion exchanger. The third lane shows the protein pattern for β -lactoglobulin, with a concentration of β -Lg of above 90%. The fourth lane shows the pattern for the a-lactalbumin fraction, which consists of above 50% a-La and less than 5 - 10% β -Lg.



Figure 6: Top left: Electrophoretic pattern of crude whey, flow through and the two eluates, a-La and β -Lg, respectively. Location of each separate whey protein on the electrophoretic pattern is indicated by an arrow. Bottom right: The chromatogram show the concentration of each protein in the a-La enriched WPI.

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Economic Calculation

UpFront Chromatography A/S has carried out cost calculations on the production of a-La- and β -Lg-enriched WPI from crude whey. In order to make such calculations it is necessary to make several assumptions. The costs of water, chemicals, energy and labour differ across countries. This calculation is based on the average prices in northern Europe and may be considered at the upper level of costs around the world. Also, the calculation does not include interest and depreciation.

Assumptions Process volume: Whey type: Protein recovery: Processing time:	Litre of whey per day Crude acid or sweet cheese whey 6 g protein per litre of whey (0.6%) 24 hours a day, 300 days a year	522,000 L
Investment 2 x 1.6m Rhobust [®] Flex EBA column(s) Holding tanks, piping, valves and automation Engineering and installation Total		Euros 1,520,000 620,000 409,000 2,549,000
Annual Production Costs Resin lease Chemicals Water Waste water treatment Labour Ultra-filtration Spray drying Total		Euros/year 729,000 98,000 17,000 216,000 114,000 619,000 1,810,000
Annual Production Produced β-Lg-enriched WPI per year Produced a-La-enriched WPI per year		562 MT 375 MT
Cost in euros in average per kg of a- and β - enriched WPI powder		Euros/kg 1.93
Annual Gross Revenue (α-La: 13 Euro/kg, β-Lg: 9.5 Euro/kg) Production costs (excluding interest and depreciation) Gross margin		Euros/year 10,214,000 1,810,000 8,404,000

Conclusion

Rhobust Whey Refinery is a cost-efficient concept for whey protein separation. The EBA technology eliminates pre-treatment of the whey and ensures high capacity and fast flow rate. The water recycling system reduces water consumption to a minimum, and, together with mild buffer solutions and a chemical recovery system, it is possible to reduce costs to a minimum and reduce the environmental impact.

About Upfront Chromatography A/S

Upfront Chromatography A/S is a Danish biotech company serving the food ingredient sector by supplying food processing plants with systems that enable the recovery of high value functional proteins from low value, high volume raw material and waste streams.

For customised separation services, Upfront offers access to its proprietary Rhobust[®], a universal process platform, combined with extensive technical and regulatory support. From a feasibility study to the commissioning of the final installation, Upfront works with its customers to develop adsorbents, ligand chemistry, columns and other hardware to optimise process performance.

Visit Upfront at www.upfront-dk.com