Extraction of Milk Oligosaccharides from Lactose Mother Liquor

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1 SUMMARY

Oligosaccharides are a diverse group of bioactive sugars that are a critical part of a new-born's nutrition. In particular, sialylated oligosaccharides have been shown to be beneficial in stimulating brain development and providing resistance to infection in the first months of life, among many other benefits. Breast milk is naturally rich in these molecules and is the best possible diet for an infant, whereas infant formula based on cows' milk is much lower in oligosaccharides.

Because of the large throughput of the dairy industry, there is an opportunity to separate and enrich the small fraction of oligosaccharides to create an ingredient with a higher oligosaccharide content that could be added to infant formula to provide formula-fed babies with a level of nutrition closer to breast milk. Lactose mother liquor is a low value by-product of lactose manufacture and has been identified to have one of the highest oligosaccharide contents of any dairy stream, including a significant portion of sialylated oligosaccharides. The objective of this work was to develop a food grade, industrial scale process for enriching oligosaccharides from mother liquor to at least 4% on a dry basis.

While the laboratory characterisation and high purity isolation of milk oligosaccharide species has developed significantly in the past 20 years, there is comparatively little understanding of high volume separations from process sources. This presents an opportunity to research the behaviour of oligosaccharides and other components of lactose mother liquor in different separation systems.

Technologies were initially evaluated by mass balances and economic criteria, with reference to final oligosaccharide purity and yield, likely production cost, and food safety considerations. Nanofiltration and size exclusion chromatography had distinct advantages in these areas, while other technologies were likely to either give poor purity for their cost or product with non-food grade chemicals.

A process was selected that centres on simulated moving bed chromatography, a continuous separation of the smaller lactose, monosaccharide, and mineral components of ultra-filtered mother liquor which are more strongly retained on a size exclusion resin from the larger oligosaccharides. A four-column laboratory scale system was built and used in trials to determine its suitability, with results showing that a raffinate containing up to 35%

oligosaccharides on a dry basis could be obtained at a flow rate of 145 mL/hour (1.03 column volumes/hour).

Nanofiltration was also trialled for the separation of oligosaccharides from ultra-filtered mother liquor, but the size difference between oligosaccharides and lactose is too small for current membrane technology to separate completely and a maximum enrichment of 2.5% (dry basis) oligosaccharides was reached. This is lower than the 4% minimum oligosaccharide requirement which is needed to meet the minimum oligosaccharide to lactose ratio. Attempts to optimise nanofiltration using lactose crystallisation and multiple nanofiltration stages gave small improvements but still fell short of the 4% target.

A sequence consisting of decanting, ultrafiltration, simulated moving bed chromatography, and evaporation was chosen as the recommended process for oligosaccharide enrichment.

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