Lactose Fouling of Ion Exchange Technology

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ABSTRACT

Cheese whey is an ingredient used in infant formulae manufacture. Before addition, the cheese whey is fully demineralised using Ion Exchange (IE) technology. Investigation of the IE process revealed low lactose yields. The objective of this thesis was to provide an understanding of the mechanism causing these low yields. This understanding may be used to improve these yields during IE processing.

Two mechanisms were proposed for the removal of lactose during IE processing namely resin entrapment and lactose mutarotation adsorption. Investigations of the mechanisms were performed with both continuous and batch benchtop methods. Whey, lactose and DMSO/lactose feed solutions were employed with various resins. DMSO/lactose solution experiments were inconclusive in determining the mechanism. Whey and lactose trials revealed lactose adsorption occurred predominantly onto the macroporous anion resin (0.09 g-lactose/g resin) compared with the gel cation resin (0.04 g-lactose/g resin). In comparison the maximum lactose adsorption onto an alternative gel structured anion resin was shown to be 0.05 g-lactose/g resin. Absorption isotherm results were dependent on the supernatant concentration. The majority of lactose adsorbed onto both the macroporous and gel anion resins was recovered with six and three equivalent volumes of water, respectively.

The adsorption dependency on the resin structure and supernatant concentration coupled with the recovery of adsorbed lactose with water proved that the resin entrapment mechanism was causing the low lactose yields. In hindsight the DMSO results were also consistent with the resin entrapment mechanism causing the low lactose yields.

It is recommended that to reduce lactose losses during IE processing by 43%, gel structured anion resin (A847S) should be coupled in series with the existing gel structured cation resin (C100H). The gel anion resin would also halve the anion water requirements during lactose recovery flushing.

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GLOSSARY OF TERMS

IE	Ion Exchange – the whey demineralisation process investigated
COD	Chemical Oxygen Demand – a measure of effluent concentration
DVB	Divinyl Benzene – a monomer responsible for the crosslinking of the resin polymer matrix
BOD	Biological Oxygen Demand – a measure of effluent concentration
SNA	Solids Non Ash - Organic components remaining after evaporation of the solvent. Sample SNA calculated from the sample TS less the sample Ash (inorganic)
RO Water	Reverse Osmosis Water – water purified through a reverse osmosis plant
DMSO	Dimethyl Sulphoxide – a polar solvent used to inhibit mutarotation
NF Whey	Nanofiltered Whey – whey processed through a nanofiltration plant
F:R Ratio	Feed:Resin Ratio – the ratio of feed solution processed through a fixed resin volume size
TS	Total Solids – Organic and inorganic components remaining after evaporation of the solvent
BV	Bed Volume – a liquid volume equivalent to the volume occupied by the immersed resin

1.0 GENERAL INTRODUCTION

Anchor Products Waitoa manufactures dairy powders for human infant consumption. These powders utilise demineralised cheddar cheese whey as an ingredient. The cheddar cheese whey is fully demineralised using Ion Exchange (IE) technology. The demineralised whey comprises predominantly lactose solids. Smaller quantities of whey proteins are also contained in the demineralised whey.

During investigation of the IE process it was noted that:

1. Lactose yields were low.
2. Effluent concentrations (>3,000 mg COD/L) were greater than literature recommendations (1700-2200 mg COD/L).
3. The pH of the eluted demineralised whey varies considerably in pH during the process run, ranging from pH 11 to pH 4.
4. Protein yields were also low.
5. A white flocculant was observed towards the end of the processing run, when the pH was low. It was thought this contained precipitated protein.

It was thought that the lactose removal might contribute to the pH process variations and the high effluent concentration. It was also speculated that the pH variations might cause protein precipitation in the columns. Protein precipitation was considered outside the scope of this thesis. The objective of this thesis was to provide an understanding of the mechanism causing lactose removal during IE processing. An understanding of how the lactose was removed may be used to improve the process.