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Dried buttermilk containing galactooligosaccharides—process layout and its verification

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Abstract

Galactooligosaccharides (GOS) are beneficial to human health and can be produced from lactose on the ground of β-galactosidase transferase activity. The aim of this work was to obtain dried buttermilk with maximal concentration of GOS. The laboratory trials with enzyme (Maxilact LX 5000) concentrations 0.1%, 0.4%, 0.8%, 1.2%, 1.6% and 2% (v/v) were made at first. Pilot experiment was carried out on spray dryer Niro Atomizer with the mixture of evaporated buttermilk and 15% (v/v) of ultrafiltration permeate and the enzyme concentration of 0.1% was chosen. Saccharides were analysed by HPLC. Degree of lactose conversion achieved 58.5% and 71.0% after 80 min (start of drying) and 130 min (end of drying) respectively. The final product contains 70 g/kg of GOS. There is no significant residual enzyme activity in dried buttermilk.

Keywords: Lactose; β-galactosidase; Galactooligosaccharides; Buttermilk

1. Introduction

Galactooligosaccharides (GOS) are resistant to hydrolysis by intestinal digestive enzymes and have physiological effects similar to those of the dietary fibre (Morishita, Oowada, Ozaki, & Mizutani, 2002). The ingestion of these oligosaccharides encourages the proliferation of bifidobacteria and lactobacilli in the intestine, which are considered to be beneficial to human health (Alander et al., 2001; Palframan, Gibson, & Rastall, 2002). Gopal, Sullivan, and Smart (2001) report on the ability of GOS in a commercial milk powder to support the in vitro growth of two selected strains of probiotic bacteria. Popularity and application of GOS as food ingredient (e.g. bifidogenic factor in infant formulae) is increasing (Schaafsma, 2002). Another benefit resulting from transforming lactose into oligosaccharides is the manufacture of low-lactose milk. It is well known that more and more people around the world suffer from gastrointestinal problems because of the high lactose content in the milk products, so-called lactose intolerance (Alm, 2003). The search for its solution has begun in the early 1970s and it still continues. In the last 30 years many products with hydrolysed lactose were investigated—e.g. yoghurts, buttermilks, cottage cheese, milks, fermented milks, whey drinks, milk powders, desserts or ice creams. There is currently more than 100 different products on the market in Finland which is very significant producer of products with hydrolysed lactose in Europe (Jelen & Tossavainen, 2003). GOS can be produced from lactose using galactosyltransferase activity of the enzyme β-galactosidase (E.C. 3.2.1.23). Galactosyl is transferred to some primary alcohol group, preferentially from D-glucose. Hydrolysis of the glycosidic bond is a special case of transglycosylation in which the galactosyl acceptor is water (Crittenden & Playne, 1996). Lactose hydrolysis could cause

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some nutritional or technological problems, e.g. in case of spray drying could get to losses of available lysine due to the Maillard reaction—condensation between amino group and carbonyl group (Morales & Arnoldi, 1999). Burvall (1978) noted 35–40% losses of available lysine with no visible changes in colour (no significant browning) and no changes in digestibility in comparison with unhydrolysed milk. Burin, Buera, Hough, and Chirife (2002) confirm the occurrence of chemical changes related to non-enzymatic browning without macroscopic changes and show the effect of the remaining enzyme activity in milk powder on colour changes during the storage. The type and amount of GOS produced could be regulated by the operating conditions (Rustom, Foda, & López-Leiva, 1998). Fungal enzymes (e.g. from *Aspergillus* sp.) and yeast enzymes (e.g. from *Kluyveromyces* sp.) form maximum of GOS at achievement the degree of hydrolysis 40–50% (50 °C, pH 4.5) and 70–80% (37 °C, pH 7) respectively (Prenosil, Stuker, & Bourne, 1987). Formation of oligosaccharides increases with increasing lactose concentration and slightly higher oligosaccharide yields were found at higher temperatures (Boon, Janssen, & van't Riet, 2000). The aim of this work was the layout of the process for production of dried buttermilk containing GOS and its verification. It can be used e.g. as component of fermented products with probiotic microflora.

2. Materials and methods

Reconstituted dried buttermilk (PML Nový Bydžov, Czech Republic) was used as substrate for laboratory trials. It contains 41.7% dry matter and 21.9% lactose. Enzyme Maxilact LX 5000 was supplied by DSM Foods (Netherlands). Pilot scale test was performed in PML Nový Bydžov using spray dryer Niro Atomizer with capacity 150 kg removed water per hour. Lactose and products of enzymatic reaction were determined by HPLC with ELS detector (Eurosep Instruments, France) and fructose as internal standard (Anonym, 2001). Samples were deproteinized by ethanol and centrifugation. Ethanol from supernatant was evaporated, the sample was dissolved in water and microfiltered (0.45 μm, Macherey–Nagel, Germany). Saccharides were separated at 80 °C on cation exchanger column in Ca^{2+} form (Ostion LG KS 0800, Watrex, Czech Republic) with deionised water as mobile phase. The degree of hydrolysis (DH) was calculated as $((C_{\text{initial lactose}} - C_{\text{lactose}})/C_{\text{initial lactose}}) \times 100$. The process was monitored by estimation of glucose by blood glucose meter One Touch II (Lifescan, USA). The residual enzyme activity in the buttermilk powder was tested with lactose addition (4.5%) to reconstituted buttermilk (dry matter was 10%) at 43 °C. Hydrolytic activity was evaluated by the spectrophotometric determination of glucose (Bio La Test Glucose GOD 250, Lachema Brno, Czech Republic) four times during 1 h.

3. Results and discussion

The process for dried buttermilk with GOS was proposed on the basis of duplicate preliminary laboratory trials. During these experiments dose of enzyme was optimised. Fig. 1 shows the results from laboratory experiments with enzyme concentrations from 0.1% to 2% (v/v) and with reconstituted buttermilk (dry matter 41.7%) as substrate at 43 °C. Opposing requirements on process conditions should be fulfilled: low enzyme concentration (minimum enzyme costs), shortest time of reaction (microbial problems), stability of GOS before drying (elimination of inactivation of β-galactosidase by heat treatment). Concentration of 0.1% was chosen, because in this case was achieved sufficient GOS stability for drying period and satisfactory time of reaction.

Pilot experiment (Fig. 2) was carried out with the mixture of evaporated buttermilk and 15% (v/v) of ultrafiltration permeate (300 l of mixture with final dry matter

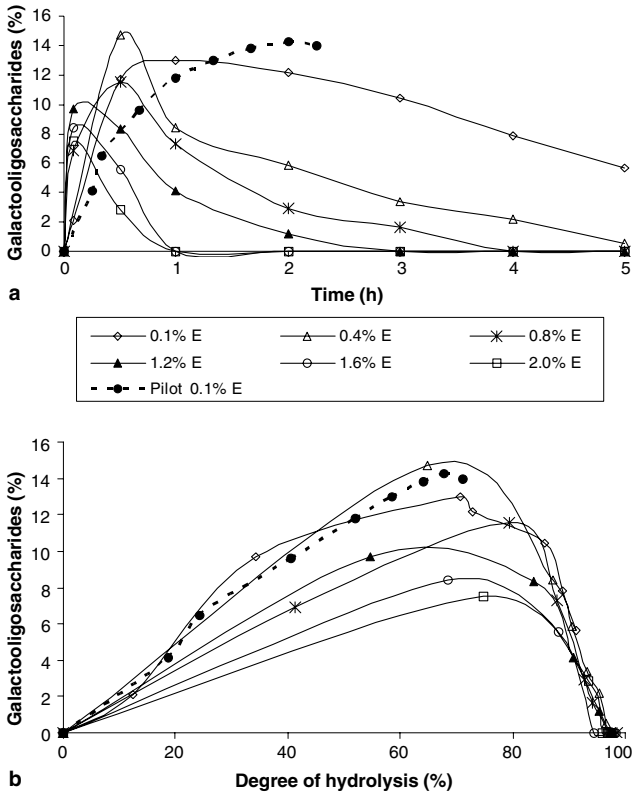

Fig. 1. Formation of galactooligosaccharides (expressed as percentage from initial content of lactose) during enzymatic reaction in reconstituted buttermilk at 43 °C and different β-galactosidase concentrations. Results from pilot experiment with 0.1% β-galactosidase are shown too. (a) Dependence of galactooligosaccharides content on time. (b) Dependence of galactooligosaccharides content on degree of hydrolysis. For the legend see (a).