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Separation of oligosaccharides from caprine milk whey, prior to prebiotic evaluation

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ABSTRACT

Milk oligosaccharides are believed to have beneficial biological properties. Caprine milk has a relatively high concentration of oligosaccharides in comparison with other ruminant milks and has the oligosaccharide profile closest to that of human milk. The first stage in recovering oligosaccharides from caprine milk whey, a by-product of cheese making, was accomplished by ultrafiltration to remove proteins and fat globules, leaving more than 97% of the initial carbohydrates, mainly lactose, in the permeate. The ultrafiltered permeate was further processed using a 1 kDa 'tight' ultrafiltration membrane, which retained less than 7% of the remaining lactose. The final retentate was fractionated by preparative scale molecular size exclusion chromatography to yield 28 fractions; oligosaccharide-rich fractions that were suitable for functionality and gut health promotion testing were detected between fractions 9/10 to 16/17. All fractions were evaluated for their oligosaccharide and carbohydrate profiles using three complementary analytical methods.

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1. Introduction

Human milk contains an exceptionally high level of oligosaccharides (OS), when compared with other ruminant species, namely cow and sheep (Martinez-Ferez et al., 2006b). These OS have a complex range of structures that confer prebiotic properties and are associated with growth factors and potential anti-inflammatory actions, and may also play a role in the local intestinal immune system of the breast fed infants, as most of these oligosaccharides (≥95%) are not digested in the gastrointestinal tract (Boehm, Stahl, Knol, & Garssen, 2008, chap. 12; Daddaoua et al., 2006; Lara-Villoslada et al., 2006; Martinez-Ferez et al., 2006b; Park, Juarez, Ramos, & Haenlein, 2007; Raynal-Ljutovac, Lagriffoul, Paccard, Guillet, & Chillard, 2008). However, few detailed data on OS composition are available for domesticated animal species, although caprine milk appears to be the richest source within ruminant species (Martinez-Ferez et al., 2006b).

Caprine milk has a high level of sialylated and neutral OS, with a profile similar to that of human milk and second only in quantity. Thus, caprine milk OS is a very promising functional food ingredient for human nutrition applications, especially for the supplementation of infant formulae and as prebiotic anti-inflammatory agents in inflammatory bowel disease (IBD) (Daddaoua et al., 2006; Martinez-Ferez et al., 2006b).

Numerous papers and patents deal with oligosaccharides in whey, but they mostly refer to specific galactooligosaccharides (GOS) obtained from lactose by enzymatic reaction (transgalactosylation) and do not refer to the natural milk oligosaccharides produced in the lactating mammary gland of domestic species. Some microorganisms used in cheese making can also be a potential source of enzymes with significant transgalactosylation activity. Therefore there is the possibility of GOS formation in milk; though this enzymatic transgalactosylation is only made of galactose and glucose units, and does not contain sialic acid, typical of human and other mammal species (Barile et al., 2009). The extraction of these compounds from milk is an expensive option, whereas it would be more economical to obtain them from a by-product such as cheese whey. Whey from cheese manufacture is an important and valuable by-product, accounting for 85–95% by volume of the milk and about 55% of all the milk nutrients (Nicolau, Squilassi, Cotta, Mesquita, & Queiroz, 2004; Squilassi, Oliveira, Nicolau, & Mesquita, 2004). Because of its content in organic matter, whey cannot be directly discharged to the environment.

Recent developments in membrane filtration have provided exciting new opportunities for large scale whey treatment to produce cleaner discharges as well as protein and lactose fractionation (Yorgun, Balcioglu, & Saygin, 2008). Due to its use in separating milk components by size, membrane technology is nowadays the

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