EFFECT OF BIOPOLYMER ADDITION ON THE PROPERTIES OF RENNET-INDUCED SKIM MILK GELS

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Abstract

The main objectives of this study were to determine the effect of adding different biopolymers (κ-Carrageenan, xanthan gum, guar gum, high-methoxyl pectin and gelatin) on the properties of rennet skim milk gels. A collection of techniques, namely strain-controlled rheometery, spontaneous whey separation measurements, confocal laser scanning microscopy and diffusing wave spectroscopy, were used.

The effects of these biopolymers were investigated for rennet skim milk gels made under model system and cheesemaking conditions. However, only rheological measurements were performed for samples made under cheesemaking conditions.

For samples made under model system conditions, the concentration of the biopolymer was varied from 0 wt% to 0.1 wt%. Experimental conditions, such as renneting temperature (30°C), total milk-solids (10 wt% reconstituted skim milk), pH 6.7 and rennet concentration (200 μL per 100 g sample) were kept constant.

The rheological behaviour of these samples was affected by the addition of κ-carrageenan, xanthan, guar, high-methoxyl (HM) pectin and gelatin. Both rheology and diffusing-wave spectroscopy (DWS) showed that the aggregation and gelation time and the gel strength was affected by the addition of these biopolymers. It was also shown that the syneresis behaviour, as well as the microstructure of rennet gels as imaged by confocal laser scanning microscopy (CLSM), was altered upon adding these biopolymers.

The rheological and microstructural properties of model renneted skim milk systems improved by adding small amounts (0.025 wt%) of κ-carrageenan, guar, HM pectin and gelatin, but not xanthan. Renneted skim milk containing HM pectin and gelatin had higher G^*, decreased aggregation time and gelation time and lower syneresis values as the concentration of biopolymer was increased.

On the other hand, lower G^* and higher syneresis values were obtained for samples containing higher concentrations (> 0.025 wt%) of κ-carrageenan, xanthan and guar gum. Higher syneresis index was a consequence of the presence of larger pores in these samples, as shown from the CLSM micrographs.

The effects caused by the addition of κ-carrageenan, xanthan and guar gum were believed to be due to phase separation in rennet skim milk gels containing polysaccharide, and was explained in term of a depletion-flocculation mechanism.

For rennet gels made under cheesemaking conditions (pH 6.2 with addition of 0.68 mM $CaCl_2$), it was found that the addition of xanthan, guar, HM pectin and gelatin had similar effect to that when added to samples made under model system conditions. This was due to the fact that the differences in pH and salt were known to not affect the properties of the biopolymers. However, the addition of κ-carrageenan, which was very sensitive to ions such as calcium, improved the viscoelastic properties of rennet skim milk gels made under cheesemaking conditions.

Overall, this work provides useful information on the effects of adding κ-carrageenan, xanthan, guar, high-methoxyl pectin and gelatin on the properties of rennet-induced gels.

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1 Introduction

1.1 Background

Despite the introduction and development of numerous new food products, milk and dairy products continue to play an important role in the nutrition of people in all parts of the world. Milk is a perishable food because of its high water content and an almost neutral pH. Like any other perishable foods, unless it is destined for immediate consumption, it needs to be processed into various products such as milk powders and cheese.

Traditionally, cheese was made as a way of preserving the nutrients of milk. Defined simply, cheese is the fresh or ripened product obtained after coagulation and whey separation of milk, cream or partly skimmed milk, buttermilk or a mixture of these products. Cheese is obtained by the addition of rennet to milk, which causes the milk proteins to aggregate and ultimately transform fluid milk to a semi-firm gel. World trade atlas (2002) reported that the New Zealand dairy industry exported 289,000 tonnes of cheese between June 2001 and 2002. Cheese emerged as the second highest exported dairy produce after milk powder for the NZ dairy industry.

Many processed and formulated foods are multi-component systems, containing protein/polysaccharides/fat mixtures. In order to achieve desirable functional properties in such foods, the use of various additives has been widely practised. Of particular interest in this regard, because of their ability to bind water, improve viscosity and gelation, are water-soluble, food-grade polysaccharides. Polysaccharides are already extensively used in a variety of manufactured dairy products as stabilizers and thickening or gelling agents. The current trend towards new dairy products with lower fat and lower total solids content has created a need for the use of polysaccharides.

Extensive research work has been carried out on cheesemaking, especially on understanding the physical chemistry of milk gelation, its processing conditions as well as properties. A number of papers by various authors (Dalgleish, 1979, 1981 and 1983; van Hooydonk, 1984, 1986, 1987 and 1988; Zoon *et al.*, 1988a, b, and c and 1989a and b; Walstra, 1983, 1986, 1990 and 1993) accumulated over the years have established

information on the effects of milk renneting conditions like pH, temperature, ionic strength, calcium concentration, casein concentration and the temperature history of the milk on the final property of the (cheese) product. The availability of this information had no doubt led to further research as well as application in commercial cheesemaking processes. However, there still remains a great deal to be understood in the complex interactions of proteins, fat and minerals during cheesemaking. In addition, the effect of the incorporation of polysaccharides in cheesemaking is practically unknown.

The main aim of this thesis was to study the effect of adding polysaccharides and gelatin on the gelation of skim milk by the addition of rennet, which is an important step in cheesemaking. Hence, an investigation of the effect of kappa (κ-) carrageenan, xanthan gum, guar gum, high-methoxyl (HM) pectin and gelatin, on the properties of rennet-induced skim milk gels will be presented.

1.2 Thesis Outline

This thesis seeks to provide an understanding on the effects of adding biopolymers like κ-carrageenan, xanthan, guar, HM pectin and gelatin on the properties of rennet-induced skim milk gels.

Chapter 2 reviews the literature and summarises the knowledge relevant to rennet-induced milk gels and milk protein/polysaccharides interactions. The scope of the project limits the review primarily to rennet-induced skim milk gels as well as understanding properties of the biopolymers used in this research.

Chapter 3 describes the analytical methods used in this research work. Brief background information on the methods used is included before detailing the experimental conditions.

Chapter 4 discusses the effect of polysaccharide as well as gelatin addition on the rheological properties of rennet-induced skim milk gels using a stress-controlled rheometer.

Chapter 5 reveals the microstructure of renneted skim milk containing polysaccharides and gelatin, and supports the findings through syneresis measurements.

Chapter 6 displays results of one recent analytical technique, Diffusing wave spectroscopy (DWS). The effect of adding polysaccharides and gelatin on the extent of aggregation and gelation time on rennet-induced skim milk was examined.

Rheological properties of renneted skim milk containing polysaccharides and gelatin in a commercial cheesemaking conditions are presented in Chapter 7.

Chapter 8 gives a general discussion highlighting the interactions involving renneted casein micelles and the biopolymers used.

Finally, the thesis closes with the final chapter summarising the major conclusions and recommendations.