

Dipl.-Chem Axel Syrbe, Clarens/Schweiz

Polymer Incompatibility in Aqueous Whey Protein and Polysaccharide Solutions

Phase Separation Phenomena and Microgel Particle Formation

Reihe **14** Landtechnik/
Lebensmitteltechnik

Nr **86**

Contents

<u>Abbreviations</u>	VIII
<u>Summary</u>	IX
<u>1 Introduction</u>	1
<u>2 Objectives</u>	4
<u>3 General background</u>	
3 1 Polymer solutions The thermodynamics	
Ideal mixing behaviour and polymer solutions	6
Entropic contributions to the non ideality of polymer solutions	7
Additional enthalpic contributions to the non ideality of polymer solutions	10
Important thermodynamic properties of polyelectrolyte solutions	12
Phase separation phenomena in polymer solutions	13
3 2 Polymer solutions Kinetic aspects of phase separation	
Nucleation & growth in the metastable range	23
Spinodal decomposition in the unstable region	23
Using polymer incompatibility as a tool for structure engineering	26
3 3 Aqueous ternary biopolymer solutions	
Separation techniques in biochemistry	30
Structural and rheological properties of mixed biopolymer gels	31
Mixing behaviour of several aqueous protein + polysaccharide systems	32
<u>4 Materials and methods</u>	
4 1 Raw materials	
Whey protein Main physicochemical properties selection and purification of whey protein isolates	39
Nonionic and anionic polysaccharides Basic molecular properties and selection	43
Other chemicals	49

4 2 Analysis methods	
Chemical analytics Nitrogen polysaccharide dry matter ash cations phosphorus chloride lactose fat SDS PAGE galacturonic acid content and degree of methyl esterification of pectin	50
pH measurements	53
Centrifugation parameters	53
HPLC procedure Determination of individual whey protein fractions	54
Dissolution of WP microgel particles	55
DSC measurements Whey protein denaturation temperature and denaturation enthalpy	55
Intrinsic viscosity measurements Determination of bulkiness	56
4 3 Microscopy	
Optical microscopy Phase contrast differential interference and fluorescence microscopy	57
Electron microscopy Transmission and scanning electron microscopy	61
4 4 Light scattering techniques	
Static light scattering techniques Determination of biopolymer molecular weights radii of gyration and size distributions of WP gel particle suspensions	63
Dynamic light scattering Hydrodynamic radii of biopolymers	71
4 5 Determination of phase diagrams	
Choice of phase diagram determination method	75
Preparation of whey protein and polysaccharide stock solutions	77
Mixing procedure and separation of equilibrium phases	79
4 6 Thermal high pressure and high shear processing techniques	
Tubular heating apparatus Heating profiles	82
High pressure device Operating conditions	89
Closed loop reactor with integrated gear rim machine Combined heat and shear treatment	89
<u>5 Experimental results and discussion</u>	
5 1 Characterization of whey protein isolate and polysaccharides	
Whey protein isolate α lactalbumin and β lactoglobulin composition	92
Composition and molecular properties of polysaccharides	108

5 2	Screening of whey protein and polysaccharide incompatibility	
	<i>Incompatibility in native whey protein + polysaccharide systems</i>	119
	<i>Heat induced incompatibility in whey protein + polysaccharide systems</i>	123
	<i>Consequences for microgel particle creation</i>	141
5 3	Phase diagrams of native whey protein α lactalbumin and β lactoglobulin + nonionic polysaccharide solutions	
	<i>Influence of polysaccharide type molecular weight and temperature on the phase separation behaviour of whey protein + nonionic polysaccharide solutions</i>	142
	<i>Phase separation behaviour of aqueous α lactalbumin and β lactoglobulin+ methylcellulose solutions</i>	153
	<i>Comparison of the phase separation behaviour of commercial WPI</i>	157
5 4	Thermal processing of incompatible whey protein + polysaccharide solutions	
	<i>Freezing liquid phase morphologies by thermal gelation of the whey protein phase</i>	168
	<i>Heat load dependent competition of phase separation and gelation</i>	192
5 5	Phase separation in α lactalbumin + methylcellulose solutions	
	<i>pH dependent competition of phase separation and gelation</i>	202
5 6	Heat and high pressure processing of whey protein + pectin solutions	
	<i>Effect of heating profile and composition on the morphology of whey protein microgel particles</i>	206
	<i>Ternary WP + HM pectin solutions and high pressure processing</i>	220
5 7	Combined high shear and thermal processing of binary whey protein solutions	
	<i>Microstructural properties of high shear whey protein gel particles</i>	225
6	<u>Conclusions</u>	
	<i>Classification of microstructure formation in ternary whey protein + polysaccharide solutions</i>	233
7	<u>References</u>	238