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Spray Dried Milk-Protein Stabilized Emulsions with High Oil Content

A thesis presented in partial fulfilment of the requirements for the degree of

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Abstract

This study explores the behaviour of oil droplets in milk protein-stabilized emulsions during spray drying. The impact of preheat treatment on the stability of oil droplets during drying in milk protein-stabilized emulsions in maltodextrin was also observed, using a variety of techniques such as particle size analysis, various microscopy techniques and sodium dodecyl sulphate polyacrylamide gel electrophoresis. In the last section of the study, the stability of the powdered emulsions was investigated against oxidative deterioration when soybean oil was replaced with fish oil in the emulsion formulation.

The results showed that spray drying and redispersion of the powdered emulsions in water (at similar total solids content) caused a shift in the droplet size distribution to larger values for all emulsions made using low concentration of whey protein isolate or sodium caseinate (0.5–2.0%, w/w w.b.), in comparison with their respective parent emulsions. However, the droplet size distribution was affected only very slightly by spray drying when the protein concentration was above 2.0% (w/w). This minimum concentration of protein that was required to produce emulsions that were stable during the spray drying process was 3.0% (w/w) for the emulsions prepared using aggregated milk protein products as compared with 2.0% (w/w) for the NaCas- and WPI-containing emulsions.

It was suggested that the amount of unadsorbed protein in the bulk phase of the parent emulsions play a crucial role in stabilizing the oil droplets during spray drying. When the surface of the oil droplet is saturated with protein molecules and the bulk phase of the emulsion has sufficient unadsorbed protein, the oil droplet is
Abstract

stable during drying. However, for emulsions with a low concentration of unadsorbed protein in the bulk phase ($\leq 1.0\%$ for WPI or NaCas emulsions), protein molecules could potentially migrate from the surface of the oil droplet to the air–water interface, causing “gaps” in the oil droplet interface and leading to coalescence and/or bridging flocculation.

Emulsions containing low levels of maltodextrin showed marked coalescence during spray drying and redispersion even at a WPI concentration of 10.0% (w/w). Above a critical concentration (12.0%, w/w), maltodextrin appeared to stabilize proteins at the interface and provide adequate rigidity to the matrix perhaps by forming a glass, under the drying conditions.

In whey protein-stabilized emulsions made with preheat treated protein solution (above 70ºC), a shift was observed in average droplet diameter towards the larger size range, because of droplet coalescence as a result of spray drying. This was thought to probably be a result of protein aggregation in emulsions, which adversely affected the ability of proteins to stabilize the emulsion droplets during spray drying and further emphasized the crucial role of monomeric whey proteins. A reduction in the non-adsorbed monomeric whey proteins as a result of preheat treatment led to oil droplet coalescence during drying. The stability of the emulsion made with pre-heat treated whey proteins was noticeably improved when NaCas was added to the emulsion either before or after the homogenization step. This improved stability was believed to be a result of the steric effect of caseins that prevented large-scale aggregation of whey proteins.

The stability of emulsions during drying as shown by the change in the average droplet diameter before and after drying showed a negative correlation with
oxidative stability of these emulsion where soybean oil was replaced with fish oil. The protein content and preheat treatment also showed a positive impact on the oxidative stability of spray-dried emulsions.

Overall, the finding from this systematic study has advanced the understanding of the mechanisms of the stability of oil droplet during drying as well as the impact of emulsions components and processing conditions. This may help to design emulsion formulations and processes and extend the applications of milk-protein stabilized powdered emulsions with high oil content.
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Contents

Abstract...........................................................................................................i

Acknowledgements..........................................................................................v

List of Figures...................................................................................................xvii

List of Tables....................................................................................................xxix

List of Publications..........................................................................................xxxi

Chapter 1  Introduction......................................................................................1

Chapter 2  Review of literature.........................................................................5

  2.1 Introduction...............................................................................................5
  2.2 Emulsion formation....................................................................................7
  2.3 Emulsion stability.......................................................................................10
    2.3.1 Creaming/sedimentation.................................................................10
    2.3.2 Flocculation.......................................................................................11
      2.3.2.1 Depletion flocculation..............................................................12
      2.3.2.2 Bridging flocculation..............................................................15
    2.3.3 Coalescence.......................................................................................17
    2.3.4 Ostwald Ripening..............................................................................18
  2.4 Milk protein-stabilized emulsions..............................................................19
    2.4.1 Caseins as adsorbed biopolymers....................................................22
    2.4.2 Whey proteins as adsorbed biopolymers.........................................25
  2.5 Factors affecting the stability of milk protein-stabilized emulsions..........27
Contents

2.5.1 Effect of homogenisation pressure…………………………….27
2.5.2 Effect of protein concentration………………………………...27
2.5.3 Effect of pH……………………………………………………28
2.6 Heat induced changes in emulsions stabilized with milk proteins………28
2.6.1 Heat treatment of milk proteins…………………………….….29
2.6.2 Impact of heat treatment in milk protein-stabilized emulsions...31
2.7 Spray drying: technical summary………………………………….…..35
2.7.1 Atomisation………………………………………………….…36
2.7.2 Droplet-hot air contact………………………………………....37
2.7.3 Water evaporation……………………………………………...38
2.7.4 Powder separation……………………………………………...39
2.8 Properties of dried emulsions……………………………………….…40
2.8.1 Surface composition……………………………………………40
2.8.2 Reconstitution…………………………………………….…....43
2.8.3 Storage stability…………………………………………….….43
2.9 Influence of emulsion components and processing conditions on the
stability of powdered emulsions……………………………………….45
2.9.1 Influence of emulsion composition……………………………...45
2.9.1.1 Proteins……………………………………………………..45
2.9.1.2 Carbohydrates..…………………………………………….47
2.9.2 Influence of processing parameters………………………..…..48
2.10 Application of spray drying for microencapsulation of long chain
polyunsaturated fatty acids…………………………………………….50
2.11 Objectives………………………………………………………….52
2.11.1 Experimental approach……………………………………….…52
Chapter 3  Materials and equipment

3.1 Materials

3.1.1 Whey protein isolate

3.1.2 Sodium caseinate

3.1.3 Milk protein concentrate

3.1.4 Calcium caseinate

3.1.5 Soybean oil

3.1.6 Maltodextrin

3.1.7 Chemicals

3.2 Equipment

3.2.1 Centrifuge

3.2.2 Water bath

3.2.3 pH meter

3.2.4 Hand held homogeniser

3.2.5 Microfluidizer

3.2.6 Spray Dryer

3.2.7 Particle size

3.2.8 Confocal laser scanning microscope

3.2.9 Scanning electron microscope

3.2.10 Transmission electron microscope
Chapter 4  Behaviour of oil droplets during spray drying of milk-protein-stabilized oil-in-water emulsions

4.1 Abstract………………………………………………………………..65
4.2 Introduction……………………………………………………………66
4.3 Materials and methods…………………………………………………68
4.3.1  Emulsion preparation…………………………………………..68
4.3.2  Spray drying……………………………………………………69
4.3.3  Determination of average droplet diameter…………………70
4.3.4  Total unadsorbed protein concentration…………………….71
4.3.5  Confocal scanning laser microscopy…………………………..72
4.3.6  Data analysis………………………………………………...…72
4.4 Results and discussion…………………………………………………74
4.5 Conclusions…………………………………………………………….92

Chapter 5  Influence of protein concentration on the stability of oil-in-water emulsions formed with aggregated milk proteins during spray drying

5.1 Abstract………………………………………………………………...93
5.2 Introduction…………………………………………………………….95
5.3 Materials and methods…………………………………………………97
5.3.1  Emulsion preparation…………………………………………..99
5.3.2  Spray drying……………………………………………………99
5.3.3  Determination of average droplet diameter…………………99
5.3.4  Total unadsorbed protein concentration………………………100
5.3.5  Total extractable oil…………………………………………..101
## Chapter 6 Impact of heat treatment on the stability of whey-protein-based oil-in-water emulsions during spray drying

### 6.1 Abstract

### 6.2 Introduction

### 6.3 Materials and methods

#### 6.3.1 Emulsion preparation – preheat treated WPI emulsions (PW)

#### 6.3.2 Emulsion preparation – heat treated WPI emulsions

#### 6.3.3 Spray drying

#### 6.3.4 Determination of average droplet size

#### 6.3.5 Confocal microscopy

#### 6.3.6 Transmission electron microscopy

#### 6.3.7 Polyacrylamide gel electrophoresis (PAGE)

#### 6.3.8 Densitometry
Chapter 7  Influence of heat treatment on the stability, during spray drying, of oil-in-water emulsions made using mixtures of whey protein isolate and sodium caseinate

7.1 Abstract..............................................................161
7.2 Introduction...........................................................163
7.3 Materials and methods..............................................166
  7.3.1 Emulsion preparation and heat treatment - Set 1........166
  7.3.2 Emulsion preparation and heat treatment – Set 2......167
  7.3.3 Spray drying ......................................................171
  7.3.4 Determination of average droplet diameter..............171
  7.3.5 Polyacrylamide gel electrophoresis (PAGE)............172
  7.3.6 Data analysis......................................................172
7.4 Results.....................................................................................173
7.5 Discussion...............................................................................186
Chapter 8  Emulsion composition and its impact on oxidative stability of the resulting spray dried powders

8.1 Abstract
8.2 Introduction
8.3 Materials and methods
  8.3.1 Emulsion preparation
  8.3.2 Spray drying
  8.3.3 Determination of average droplet diameter
  8.3.4 Water activity
  8.3.5 Total extractable oil
  8.3.6 Analysis of hydroperoxide content
  8.3.7 Determination of propanal by static headspace gas chromatography
  8.3.8 Data analysis
8.4 Results
8.5 Discussion
8.6 Conclusions

Chapter 9  Overall discussion and avenues of future work
Contents

References .................................................................................................................................. 233

Permissions .................................................................................................................................. 265
List of Figures

Figure 2.1 Schematic representations of the different types of emulsion systems. Blue and yellow represent water and oil phase respectively (adapted from Emulsions & Emulsification, 2009)…………………………………………………………6

Figure 2.2 Preparation of an emulsion from separate oil and water phase using an emulsifier and a high pressure homogeniser (a schematic representation adapted from McClements, 2010)……………………………………………………….9

Figure 2.3 Schematic representation of mechanisms for droplet instability in oil-in-water emulsions. Yellow represents the oil phase whereas blue represents the aqueous phase (adapted from McClements and Weiss, 2005)…………………..13

Figure 2.4 A schematic representation of depletion flocculation where biopolymers with radius of gyration (R_g) are excluded/depleted from the solution between spherical particles (radius = a) (Walstra, 1993; Ye, 1999)……………………………..14

Figure 2.5 A schematic representation of bridging flocculation in oil-in-water emulsion where oil droplets (yellow) are bridged together by biopolymers (blue line) (Adapted from Sarkar, 2010)…………………………………………………………16

Figure 2.6 A schematic representation of Ostwald ripening (adapted from Taylor, 1998). Oil droplet is represented in yellow and the continuous phase (water) is represented by blue………………………………………………………………19

Figure 2.7 Schematic of αs1- casein and β-casein illustrating the ‘loop-like’ anchoring of αs1- casein and the ‘tail-like’ anchoring of β-casein on to a hydrophobic interface. The larger circles depict the range of electrostatic repulsion
arising from the negative charge centres and the smaller circles depict the hydrophobic regions (Singh & Ye, 2009)…………………………………………23

**Figure 2.8** Schematic representation of the aggregation process in β-lactoglobulin systems at pH > 5.7. The process starts with the dissociation of dimers into monomers as a result of denaturation (step 1). Larger oligomers start to form with the progression of heating (step 2). Above a critical concentration of protein, larger primary aggregates are formed which may vary in shape and size (step 3). With further progression of the process, self-similar aggregates may be formed, which may precipitate or gel formation may occur (step 4). The scale in the schematic changes at step 3 and 4 (Adapted from Nicolai et al., 2011)……………………………………30

**Figure 2.9** Schematic representing the effect of heating on emulsions containing whey proteins alone and in emulsion containing both whey proteins as well as caseins. Whey protein adsorbed at the oil interface (a), whey proteins and caseins co-adsorbed at the oil interface with tails of the casein molecules protruding/dangling out of the interface (b), flocculation of emulsion droplets in whey protein stabilized emulsions due to heat treatment above 75°C (c) and sterically stabilized emulsion droplet due to caseins tails (d) (Adapted from Dickinson & Parkinson, 2004)………………………………………………………………………34

**Figure 2.10** A Schematic representation of the spray drying process (multi-stage dryer) commonly used in the manufacture of dairy products (Spray Dryer MSD™ Spray Dryer, 2015)………………………………………………………………………………37

**Figure 2.11** Representation of the drying mechanism of a single milk particle as a function of residence time in the drying chamber (Birchal et al., 2006; Kim et al., 2008)……………………………………………………………………………………………………39
Figure 2.12 A model depicting the different locations where free fat may exist in the powder particle available for extraction using organic solvent (Buma, 1971)……………………………………………………………………………………………………. 41

Figure 2.13 Relationship between powder composition and processing parameters on the final powder properties (Verdurmen & Jong, 2003)……………………………………..49

Figure 2.14 Scanning electron micrograph showing the coating of starch (B) on powder particle surface (A) (Drusch & Mannino, 2009)…………………………………….51

Figure 3.1 Illustration of a Y-type single slotted interaction chamber used in the preparation of the emulsions in this study………………………………………………60

Figure 3.2 Image of a B-290 bench top spray drier manufactured by Buchi laboratories, Flawil, Switzerland…………………………………………………………..61

Figure 3.3 Image of the Mastersizer 2000 E manufactured by Malvern Instruments, Worcestershire, UK………………………………………………………………..62

Figure 3.4 Image of a confocal scanning laser microscope model SP5 DM6000B manufactured by Leica Microsystems, Heidelberg, Germany…………………………63

Figure 4.1 Process flow diagram showing the emulsion preparation, spray drying and analyses for this study……………………………………………………………….69

Figure 4.2 A glass bottle showing Nile red mixed with the oil phase (top layer, fluorescent orange) and fast green mixed in the water phase (bottom phase) before emulsification of the mixture. These emulsions were specifically produced for confocal scanning laser microscopy……………………………………………….73
List of Figures

Figure 4.3a Droplet size distributions of emulsions (0.5–5.0% w/w WPI, 20.0% w/w soybean oil, 12.0% w/w MD) before spray drying (●) and after redispersion (○); whey protein isolate concentrations were: a, 0.5%; b, 1.0%; c, 1.5%; d, 2.0%; e, 2.5%; f, 3.0%; g, 4.0%; h, 5.0%.................................75

Figure 4.3b Droplet size distributions of emulsions (0.5–5.0% w/w NaCas, 20.0% w/w soybean oil, 12.0% w/w MD) before spray drying (●) and after redispersion (○); sodium caseinate concentrations were: a, 0.5%; b, 1.0%; c, 1.5%; d, 2.0%; e, 2.5%; f, 3.0%; g, 4.0%; h, 5.0%.................................76

Figure 4.4 Average droplet diameter (d_{43}) values of parent (●) and redispersed (○) emulsions containing 20.0% w/w soybean oil, 12.0% w/w MD and 0.5–5.0% w/w WPI (a) or NaCas (b). The redispersed emulsions were also diluted (1:1) with 2.0% w/w SDS solution (▼)................................................79

Figure 4.5 Total unadsorbed protein concentration (% w/w) in the bulk phase of the parent emulsions containing either WPI (●) or NaCas (○) as a function of the total protein concentration.................................................................81

Figure 4.6 Confocal micrographs of emulsion powder particles (20.0% w/w soybean oil, 12.0% w/w MD) stained with Nile red and Fast green. (A) 0.5% w/w WPI and (B) 3.0% w/w WPI. Red represents the fat phase and green represents whey proteins.................................................................83

Figure 4.7 Average droplet diameter (d_{43}) values of parent (●) and redispersed (○) emulsions (1.0% w/w MD, 20.0% w/w soybean oil) as a function of the concentration of WPI (1.0–10.0% w/w). The redispersed emulsions were also diluted (1:1) with 2.0% w/w SDS solution (▼)......................................................85

Figure 4.8 Confocal micrographs of emulsions (10.0% w/w WPI, 20.0% w/w soybean oil, 1.0% w/w MD) before (a) and after (b) spray drying.................87
List of Figures

**Figure 4.9** Average droplet diameter ($d_{43}$) values of emulsions (0.5% w/w WPI, 20.0% w/w soybean oil) as a function of the concentration of MD before spray drying (●), after redispersion of the powder in water (○) and after redispersion in water and SDS solution (▼). MD was added to the parent emulsion prior to microfluidization. ...........................................................................................................................................88

**Figure 4.10** Average droplet diameter ($d_{43}$) values of emulsions (0.5% w/w WPI, 20.0% w/w soybean oil) as a function of the concentration of MD before spray drying (●), after redispersion of the powder in water (○) and after redispersion in water and SDS solution (▼). MD was added to the parent emulsion subsequent to microfluidization. ...........................................................................................................................................90

**Figure 5.1** Process flow diagram showing emulsion preparation, spray drying and analyses for this study.........................................................................................................................................98

**Figure 5.2** Droplet size distributions of emulsions (0.5–5.0%, w/w, milk protein concentrate, 20.0%, w/w, soybean oil, 12.0%, w/w, maltodextrin) before spray drying (●) and after redispersion (○): a, 0.5%; b, 1.0%; c, 2.0%; d, 3.0%; e, 5.0% protein..................................................................................................................................................104

**Figure 5.3** Droplet size distributions of emulsions (0.5–5.0%, w/w, calcium caseinate, 20.0%, w/w, soybean oil, 12.0%, w/w, maltodextrin) before spray drying (●) and after redispersion (○): a, 0.5%; b, 1.0%; c, 2.0%; d, 3.0%; e, 5.0% protein. ..................................................................................................................................................105

**Figure 5.4** Average droplet diameter ($d_{43}$) values of parent (●) and redispersed (▼) emulsions containing 20.0% (w/w) soybean oil, 12.0% (w/w) maltodextrin and 0.5–5.0% (w/w) milk protein concentrate (MPC) (a) or calcium caseinate (CaCas) (b). The parent (○) and redispersed (△) emulsions were also diluted (1:1) with 2.0% (w/w) sodium dodecyl sulphate solution. .......................................................................................................................................107
List of Figures

Figure 5.5 Confocal micrographs of emulsions (0.5%, w/w, calcium caseinate, 20.0%, w/w, soybean oil, 12.0%, w/w, maltodextrin) stained with Nile blue: a, parent emulsion; b, redispersed emulsion after spray drying. The scale on the micrographs represents 50µm. Green arrows illustrate bridging flocculation (b).................................................................108

Figure 5.6 Total unadsorbed protein (% w/w) in the bulk phase of the parent emulsions containing either milk protein concentrate (●) or calcium caseinate (○) as a function of the total protein concentration. Each data point is the average of two determinations on separate emulsions.................................109

Figure 5.7 Total extractable oil (mg/g of powder) for powders containing either milk protein concentrate (○) or calcium caseinate (●) as a function of protein concentration in the emulsions used to make the powders.........................110

Figure 5.8 Electron micrographs of emulsion powder particles (20.0%, w/w, soybean oil, 12.0%, w/w, maltodextrin): a, 0.5% (w/w) milk protein concentrate; b, 0.5% (w/w) calcium caseinate; c, 5.0% (w/w) milk protein concentrate; d, 5.0% (w/w) calcium caseinate. Scale is 50µm (a, b) and 10 µm (c, d)..................112

Figure 5.9 Confocal micrographs of emulsion powder particles (20.0%, w/w, soybean oil, 12.0%, w/w, maltodextrin) stained with Nile red and Fast green: a, 0.5% (w/w) milk protein concentrate; b, 5.0% (w/w) milk protein concentrate. Red (and orange) represents the fat phase and green represents proteins. The black hole inside the powder particle is an air vacuole. Scale as shown on the micrographs.................................................................113

Figure 6.1a Process flow diagram showing the emulsion preparation, spray drying
and analyses for PW emulsions for this study ........................................127

**Figure 6.1b** Process flow diagram showing the emulsion preparation, spray drying and analyses for HE emulsions for this study........................................128

**Figure 6.2** Average droplet diameters \(d_{43}\) values of PW emulsions (20%, w/w, soybean oil; 12%, w/w, maltodextrin) containing 0.25–5.0% (w/w) WPI as a function of the preheat temperature (65–90°C) for 10 min before spray drying (■) and after redispersion of the powder in water (■). Also, \(d_{43}\) of emulsions upon dilution (1:1) with 2.0% (w/w) SDS solution before spray drying (□) and after redispersion (□). The WPI concentrations in the emulsions were: a, 0.25%; b, 0.5%; c, 1.25%; d, 3.0%; e, 5.0%..................................................133

**Figure 6.3** Droplet size distributions of emulsions (20%, w/w, soybean oil; 12%, w/w, maltodextrin) containing 0.5% (w/w) (a, b) and 5.0% (w/w) (c, d) WPI. These emulsions were prepared using either unheated WPI solutions (a, c) or preheated WPI solutions (b, d) at a preheating temperature of 90°C for 10 min. Parent emulsions (●), parent emulsions diluted (1:1) with 2.0% (w/w) SDS solution (○), redispersed emulsions (▼) and redispersed emulsions diluted (1:1) with 2.0% (w/w) SDS solution (△).................................................................135

**Figure 6.4** SDS-PAGE patterns under non-reducing conditions of WPI solutions at concentrations of 1.25% (w/w) (lanes 1–6) and 10.0% (w/w) (lanes 7–12) that were heated for 10 min at different temperatures: lanes 1 and 7, unheated; lanes 2 and 8, 65°C; lanes 3 and 9, 70°C; lanes 4 and 10, 75°C; lanes 5 and 11, 80°C; lanes 6 and 12, 90°C. M denotes the lane with the molecular weight marker. BSA denotes bovine serum albumin.................................................................137
List of Figures

**Figure 6.5** Percentages of residual monomeric (a) α-la and (b) β-lg remaining in 1.25% (w/w) (grey) and 10.0% (w/w) (solid) WPI solutions that were preheated for 10 min at various preheating temperatures. UH denotes unheated solutions……..139

**Figure 6.6** Average droplet diameters (d43) of HE emulsions (20%, w/w, soybean oil; 12.0%, w/w, maltodextrin) containing (a) 0.5% (w/w) and (b) 3.0% (w/w) WPI as a function of heating temperature (65–90ºC) for 10 min before spray drying (n) and after redispersion of the powder in water (□). Average droplet diameter (d43) values of redispersed emulsions upon dilution (1:1) with 2.0% (w/w) SDS solution (□)……………………………………………………..141

**Figure 6.7** Confocal micrographs of HE emulsions (0.5%, w/w, WPI; 20%, w/w, soybean oil; 12%, w/w, maltodextrin) heated at 90ºC for 10 min after spray drying and redispersion (a) in water and (b) diluted (1:1) in 2.0% (w/w) SDS. Arrows show some of the aggregates present in the micrograph. Scale is 50 µm.……..143

**Figure 6.8** SDS-PAGE patterns under non-reducing conditions of emulsions stabilized with 0.5% (w/w) (lanes 1–6) and 3.0% (w/w) (lanes 7–12) WPI that were heated for 10 min at different temperatures: lanes 1 and 7, unheated; lanes 2 and 8, 65ºC; lanes 3 and 9, 70ºC; lanes 4 and 10, 75ºC; lanes 5 and 11, 80ºC; lanes 6 and 12, 90ºC. M denotes the lane with the molecular weight marker………………..145

**Figure 6.9** Percentages of residual monomeric (a) α-la and (b) β-lg remaining in whey-protein-stabilized emulsions at WPI concentrations of 0.5% (w/w) (□) and 3.0% (w/w) (n) that were preheat treated for 10 min at various preheating temperatures. UH denotes unheated emulsions………………………………146
Figure 6.10 Average droplet diameters ($d_{43}$) values of emulsions (20%, w/w, soybean oil; 12%, w/w, maltodextrin) containing (a) 0.5% (w/w) and (b) 3.0% (w/w) WPI as a function of heating time (1–30 min) at 90°C before spray drying (■) and after redispersion of the powder in water (□). Average droplet diameters ($d_{43}$) values of redispersed emulsions after dilution (1:1) with 2.0% (w/w) SDS solution (■). The emulsions were heat treated after homogenization……………148

Figure 6.10 Percentages of residual monomeric (a) $\alpha$-la and (b) $\beta$-lg remaining in whey-protein-stabilized emulsions at WPI concentrations of 0.5% (w/w) (□) and 3.0% (w/w) (■) that were preheat treated for 1–30 min at a preheating temperature of 90°C. UH denotes unheated emulsions………………………………………..150

Figure 6.12 Transmission electron micrographs of (a–d) emulsions and (e–h) powders containing 3.0% (w/w) WPI and either untreated (a, b, e, f) or preheat treated at 90°C for 10 min (c, d, g, h). Scale as shown in the micrographs. White areas marked with arrows in some micrographs (e, f, g) represent vacuoles or air cavities at the centre of a powder particle………………………………………..151

Figure 7.1a Process flow diagram showing the emulsion preparation, spray drying and analyses for set 1 in this study………………………………………………………..169

Figure 7.1b Process flow diagram showing the emulsion preparation, spray drying and analyses for set 2 in this study………………………………………………………………..170

Figure 7.2 Droplet size distributions of emulsions containing 2.0–3.0% (w/w) whey protein isolate, 0.0–1.0% (w/w) sodium caseinate, 20.0% (w/w) soybean oil and 12.0% (w/w) maltodextrin before spray drying (●) and after redispersion (○). These emulsions were heat treated at 90°C for 10 min before spray drying (except a
and b). All emulsions were also diluted (1:1) with 2.0% (w/w) sodium dodecyl sulphate solution (▼). The whey protein isolate and sodium caseinate concentrations respectively were: a, 3.0% and 0.0% (unheated); b, 2.0% and 1.0% (unheated); c, 3.0% and 0.0%; d, 2.9% and 0.1%; e, 2.75% and 0.25%; f, 2.5% and 0.5%; g, 2.25% and 0.75%; h, 2.0% and 1.0%.......................................................175

Figure 7.3 Average droplet diameter ($d_{43}$) values of parent (blank bars) and spray dried and redispersed (solid bars) emulsions containing 20.0% (w/w) soybean oil, 12.0% (w/w) maltodextrin and 2.0–3.0% (w/w) whey protein isolate and 0.0–1.0% (w/w) sodium caseinate. The total concentration of protein in all emulsions was kept constant at 3.0% (w/w). The redispersed emulsions were also diluted (1:1) with 2.0% (w/w) sodium dodecyl sulphate solution (striped bars). UH denotes unheated emulsion………………………………………………………..…..177

Figure 7.4 SDS-PAGE patterns of the cream phase of emulsions (non-reducing) formed with a combination of whey protein isolate and sodium caseinate (a) before and (b) after heating at 90°C for 10 min. Lane 1: 3.0% WPI, 0.0% NaCas; lane 2: 2.75% WPI, 0.25% NaCas; lane 3: 2.5% WPI, 0.5% NaCas; lane 4: 2.25% WPI, 0.75% NaCas; lane 5: 2.0% WPI, 1.0% NaCas. M1 denotes unheated WPI, M2 denotes unheated NaCas and BSA denotes bovine serum albumin……………..179

Figure 7.5 Average droplet diameter ($d_{43}$) values of parent (blank) and spray-dried and redispersed (solid) emulsions containing 20.0% (w/w) soybean oil, 12.0% (w/w) maltodextrin and 2.0–3.0% (w/w) whey protein isolate and 0.0–1.0% (w/w) sodium caseinate. Sodium caseinate (in solution form) was added after homogenization of the WPI emulsions while maintaining the total protein concentration in all emulsions at 3.0% (w/w). The redispersed emulsions were also
List of Figures

diluted (1:1) with 2.0% (w/w) sodium dodecyl sulphate solution (striped). UH denotes unheated emulsion……………………………………………………………………………181

**Figure 7.6** SDS-PAGE patterns of the cream phase of emulsions (non-reducing) formed with a combination of whey protein isolate and sodium caseinate in which the sodium caseinate was added to the whey protein isolate emulsion after the homogenization step and either (a) before heat treatment or (b) after heat treatment at 90°C for 10 min. Lane 1: 3.0% WPI, 0.0% NaCas; lane 2: 2.75% WPI, 0.25% NaCas; lane 3: 2.5% WPI, 0.5% NaCas; lane 4: 2.25% WPI, 0.75% NaCas; lane 5: 2.0% WPI, 1.0% NaCas. M1 and M2, unheated whey protein isolate solution and sodium caseinate solution respectively and BSA denotes bovine serum albumin…………………………………………………………………………………………183

**Figure 7.7** Transmission electron micrographs of redispersed emulsions containing: (a) 3.0% (w/w) whey protein isolate, untreated; (b) 3.0% (w/w) whey protein isolate, heat treated at 90°C for 10 min; (c) 2.5% (w/w) whey protein isolate and 0.5% (w/w) sodium caseinate heat treated at 90°C for 10 min; (d) 2.0% (w/w) whey protein isolate and 1.0% (w/w) sodium caseinate heat treated at 90°C for 10 min. Scale as shown in each image. (c) and (d): sodium caseinate was added before the homogenization step (set 1)…………………………………………………………………………185

**Figure 8.1** Process flow diagram showing the analyses conducted for this study………………………………………………………………………………………………………………199

**Figure 8.2** Average droplet diameter ($d_{43}$) values for parent (grey bars) and redispersed (black bars) emulsions containing 20.0% (w/w) fish oil, 1.0-25.0% (w/w) maltodextrin and 0.5-10.0% (w/w) whey protein isolate and/or sodium
List of Figures

caseinate. The redispersed emulsions were also diluted (1:1) with 2.0% (w/w) sodium dodecyl sulphate solution (striped bars)……………………………………205

Figure 8.3 Total extractable oil (mg/g powder) for powdered emulsions containing fish oil (42.9%-62.9% dry basis) with varying concentration of protein (whey protein isolate and/or sodium caseinate) and maltodextrin…………………………207

Figure 8.4 Peroxide values (meq/kg oil) of various powdered emulsion formulations containing fish oil stored for 21 days at 20°C and 33% relative humidity……………………………………………………………………………209

Figure 8.5 Propanal content (μmol/kg oil) of various powdered emulsion formulations containing fish oil stored for 21 days at 20°C and 33% relative humidity……………………………………………………………………………212

Figure 9.1 Suggested course during spray drying of sprayed emulsion droplets, when (a) protein is present at a low concentration in the emulsion and (b) protein concentration is optimum………………………………………………………224
List of Tables

Table 2.1 Different types of oil-in-water emulsions and their properties (McClements, 2010)………………………………………………………………..8

Table 2.2 Overview of experimental techniques used in the study………………53

Table 3.1 Compositional details of the various protein products used in this research…………………………………………………………………………….56

Table 3.2 List of chemicals and reagents and their suppliers used in the study…..57

Table 7.1 Formulation of set 1 and set 2 emulsions used in this study…………168

Table 8.1 Composition of experimental fish oil emulsions and powders……….200

Table 8.2 Pearson correlation (coefficient) matrix for various emulsion and powder (E1-E10) parameter ……………………………………………………………...214
List of Publications

