Cryogelation of Egg White Protein

A thesis presented in partial fulfilment of the

requirements for the degree of

Master of

Food Technology

at Massey University, Manawatū,

New Zealand.

Zitong Huang

2017

Abstract

Gelation of egg white protein (EWP) solutions can be induced as a consequence of freezing and thawing in the presence of a denaturant (urea). This mechanism of cryogelation can be affected by the relative concentrations of protein and urea, as well as freezing conditions including freezing temperature and freezing duration.

The compression peak force (CPF) of the obtained cryogels was measured using large deformation texture analysis to indicate the gel strength of samples. In the range of added urea concentration from 1M to 6.6M the CPF of samples was seen to decrease, whilst increasing EWP concentration from 5% (w/v) to 15% (w/v) resulted in a strengthening of gel structure with increasing CPF. Lower freezing temperatures (e.g. -30^{o}C) caused a decrease in CPF of samples compared to -18^{o}C and samples stored for 68 hours had higher CPF than those stored for 20 hours (at 1M added urea).

Water holding capacity (WHC) of cryogel was determined by measuring the amount of released water from samples gravimetrically. With increasing concentration of urea the WHC of samples was seen to initially decreased, followed by a progressive increase as the concentration of urea was raised. This trend was observed for most protein concentration with the exception of 5% EWP which showed a significant increase at 4M urea, followed by a drop at higher urea concentrations. Increasing EWP concentrations tended to result in higher WHC in general, although samples with 10% and 12% EWP had relatively similar WHC values. WHC of samples frozen at -30^{o}C was higher than those frozen at -18^{o}C at high urea concentrations. However, increasing the frozen storage time did not appear to affect the WHC.

The microstructure of EWP cryogel was observed using scanning electric microscopy (SEM) and transmission electric microscopy (TEM). The SEM data showed a porous structure for all samples. The increase in the concentration of added urea and the decrease in freezing temperature seemed to reduce the porosity and connectivity of the structure especially at low EWP concentrations. There was also some observed difference of the gel wall thickness between some different samples. The TEM data provided a clear distribution of protein and pores within the gel phase.

The effect of urea on the thermal stability of protein molecules was studied using nano differential scanning colorimetry (nano DSC). Results showed that the addition of urea progressively denatured the protein with increasing urea concentration. Proteins appeared to be further denatured as a consequence of the freezing-thawing process.

The effect of urea addition on freezing point depression and ice content was calculated, allowing the protein content in the unfrozen phase to be determined. The relative concentrations of protein, urea, frozen and unfrozen water in the frozen state provided some indications as to how the extent of denaturation coupled with freeze concentration in the unfrozen phase contributed to the cryogels structures being formed. A number of correlations were determined that assisted in developing a mechanistic understanding of the cryogelation effect. Findings demonstrate a potential means of creating food gel structures with novel structural and material characteristics.

Acknowledgement

I sincerely appreciate the opportunity to study for my Master's degree at Massey University. Especially, I would like to express my gratitude for the supervision of Matt Golding, who has been very helpful and patient through the entire research project with his enlightening advice.

Also, I am thankful for all the technical support and advice from the technicians at Food Department with my project: Mr Steve Glasgow, Mr Garry Radford, Mr Warwick Johnson Mrs Michelle Tamehana, and Mr Chris Hall from Riddet Institute. In addition, I would like to express my appreciation for Mr Trevor Loo from Fundamental Science Department with nano DSC, and Dr Matthew Savoian, Ms Jordan Taylor and Mrs Niki Minards from MMIC with SEM and TEM imaging.

I would like to thank all my friends in New Zealand for their support and company, my flatmates, my classmates, my friends at Massey and outside Massey. Finally, I am gratefully for my families and friends back in my country who always support and encourage me even though we are thousands of miles apart.

Again, I really enjoyed the time studying at Massey in this beautiful country. I hope everyone will success with their study and career and live a happy life, and I will also move on to pursue the next step in my life.

Contents

List of Figures

List of Tables