

**STUDIES ON SOME FUNCTIONAL
PROPERTIES OF WHEY PROTEINS AND THEIR
APPLICATIONS IN SOME FOOD SYSTEMS**

By

ATIF FARRAG MOSTAFA FARRAG

B.Sc.Agric.(Dairy Sci. & Tech.) Al-Azhar Univ., 1981

M.Sc.Agric.(Dairy Sci. & Tech.) Ain Shams Univ., 1991

A thesis submitted in partial fulfillment
of
the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

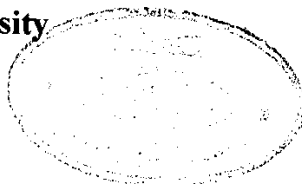
Agricultural Science
(Dairy Science and Technology)

Department of Food Science

Faculty of Agriculture

Ain Shams University

1996





Approval Sheet

**STUDIES ON SOME FUNCTIONAL PROPERTIES
OF WHEY PROTEINS AND THEIR APPLICATIONS
IN SOME FOOD SYSTEMS**

By

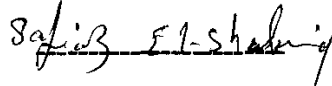
ATIF FARRAG MOSTAFA FARRAG

B.Sc.Agric.(Dairy Sci. & Tech.) Al-Azhar Univ., 1981

M.Sc.Agric.(Dairy Sci. & Tech.) Ain Shams Univ., 1991

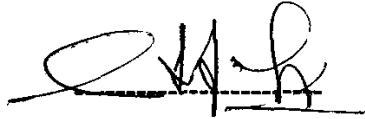
This thesis for the Ph.D degree has been approved by :

1- Prof. Dr. Safinaz El-Shibiny



Prof. of Dairy Science and Head of Food Science &
Nutrition Division, National Research Centre .

2- Prof. Dr. A.A. Hofi



Prof. of Dairy Science, Fac. of Agric., Ain Shams Univ.

3- Prof. Dr. A.A. Askar



Prof. of Dairy Science, Fac. of Agric., Ain Shams Univ.
(Supervisor) .

Date of examination : 10 / 1 / 1996

**STUDIES ON SOME FUNCTIONAL PROPERTIES
OF WHEY PROTEINS AND THEIR APPLICATIONS
IN SOME FOOD SYSTEMS**

By

ATIF FARRAG MOSTAFA FARRAG

B.Sc.Agric.(Dairy Sci. & Tech.) Al-Azhar Univ., 1981

M.Sc.Agric.(Dairy Sci. & Tech.) Ain Shams Univ., 1991

Under the Supervision of :

Prof. Dr. A.A. ASKAR

Professor of Dairy Science, Ain Shams University.

Prof. Dr. M.H. ABD EL-SALAM

Professor of Dairy Science, National Research Centre .



Abstract

Atif Farrag Mostafa Farrag. Studies on some functional properties of whey proteins and their applications in some food systems . Unpublished Doctor of Philosophy dissertation, University of Ain Shams, 1996 .

In the present study the functional properties of whey proteins and their applications in some food systems were investigated. The denaturation of whey protein concentrate as affected by different factors, was followed after heat treatment by determining the soluble nitrogen at pH 4.6 and protein fractions were followed by HPLC separations :-

- The denaturation degree was increased with increase of heating temperatures and whey protein content.

- The maximum denaturation was shown at pH 7.5 while the lowest denaturation was found at pH 3.0 and to much less affected by calcium and lactose content.

α -lactalbumin was much affected at low heating temperature than β -lactoglobulin and the reverse was observed at higher temperature.

Also the emulsifying capacity, stability and viscosity of whey proteins stabilized emulsions were followed:-

- The emulsion capacity was increased with heat treatments of WPC solutions and the emulsion stability was improved with the increase in the protein concentration

- The highest emulsion stability was shown at pH 7.5 while the lowest stability was found at pH 4.5.

- The emulsion capacity was improved with increase the oil volume in the emulsion but the further increase in the oil volume, decreased the emulsion capacity and stability.

- The addition of 0.2% pectin increased the emulsion stability and the reverse was observed with CMC and carrageenan.

-The increase of casein content in blend with whey protein solutions improved both of emulsion capacity and stability.

-The emulsion showed increased viscosities with increase the protein concentration, heat treatment, presence of lactose, increase in the oil volume, presence of stabilizers and presence of whey protein in the blends between whey protein and casein.

Also the protein patterns of skim and standardized buffalo milk were modified by addition of variable aliquots whey protein solutions. The modified milks were acidified with GDL and the gelation time, viscosity and the curd firmness were determined:-

-The curd firmness (K_{20}) of skim milk decreased with increase in the percentage of added WPC and duration time of standardized milk was generally faster than that of skim milk.

-The curd firmness (K_{20}) decreased with increase in percentage of added WPC and heat duration .

Key words : Whey protein concentrate - Functional properties
- Denaturation - β -lactoglobulin - α -lactalbumin - Emulsion capacity - Emulsion stability - Casein - Food system - Viscosity - Gelation time - Curd firmness .

Acknowledgement

The author would like to express his deepest gratitude and sincere appreciation to **Prof. Dr. A.A. Askar**, Food Science Dept., Fac. of Agric., Ain Shams Univ., and **Prof. Dr. M.H. Abd El-Salam** head of Food Technology & Dairying Dept. National Research Centre (NRC) for they kindly offered throughout the course of this work.

Many thanks are also due to **Prof. Dr. Hala.F. El-Dein**, at the Dept. of Food Tech. & Dairying at the NRC for her continous interest in this work.

Many thanks due to all staff members of Food Science Dept., Ain Shams Univ., and all staff members of Dairy Laboratory at the NRC, Cairo, for their great help .

CONTENTS

	Page
Introduction	1
Review of Literature	4
Denaturation	4
Emulsification	22
Viscosity	37
 Materials and Methods	 42
Whole and skimmed buffalo milk	42
Preparation of Whey Protein Concentrates (WPC).	42
Preparation of casein	42
Standard whey protein solutions	43
Types of oils	43
Type of stabilizers	43
Experimental	44
Methods of Analysis	47
Determination of total solids	47
Determination of nitrogen fractions	47
Determination of pH value	48
Determination of fat	48
Determination of lactose	48
Determination of calcium	49
Determination of heat denaturation of WPC	49
-Determination of nitrogen fractions	49
-High Performance Liquid Chromatography (HPLC) .	49
Determination of emulsification (capacity and stability)	51
Determination of viscosity	51
Determination of milk gelation and curd firmness	52

	Page
Results and Discussion	54
Part I: Effect of heat treatment under variable conditions on the denaturation of whey protein concentrate.	54
Part II: Emulsifying properties of whey protein solutions as affected by some factors .	87
Part III: Rheology of whey protein concentrate emulsions under variable conditions .	124
Part IV: Rheological properties of buffalo milk with modified casein/whey protein content.	154
Summary and Conclusion	188
References	195
Arabic Summary	-----

LIST OF TABLES

Table	Page
1 Chemical composition of whey protein concentrate (WPC) solutions of different protein content.	56
2 Effect of heating temperature and duration on the soluble proteins (at pH 4.6) in WPC solutions of different protein concentration.	57
3 Effect of heating temperature for 10 min on the soluble proteins at pH 4.6 in WPC of different protein concentration.	59
4 Effect of pH and Calcium content (mg/100 ml) on the percentage denaturation of WPC (4.54% protein) at 80°C for 10 min.	62
5 Effect of pH and Calcium content (mg/100 ml) on the percentage denaturation of WPC (4.54% protein) at 80°C for 10 min.	67
6 Effect of heating temperature on the denaturation percentage of α -lactalbumin (α -La) and β -lactoglobulin (β -Lg) at pH 6.0.	80
7 Effect of pH and addition of CaCl_2 (mg/100 ml) on the denaturation percentage of α -lactalbumin (α -La) and β -lactoglobulin (β -Lg) in WPC (4.54% protein heated at 80°C/10 min).	82
8 Effect of pH and addition of lactose on the denaturation percentage of α -lactalbumin (α -La) and β -lactoglobulin (β -Lg) in WPC (4.54% protein heated at 80°C/10 min).	85
9 Chemical composition of WPC solutions at different protein contents, used for emulsification experiments.	88

Table		Page
10	Emulsifying capacity (m^2/g) of the emulsion prepared with different whey protein concentrate, heated at various temperature and corn oil (3:1).	89
11	Emulsifying capacity and stability (m^2/g) for emulsions prepared with heated and unheated 0.51% whey protein concentrate and corn oil (3:1).	92
12	Emulsifying capacity and stability (m^2/g) for emulsions prepared with heated and unheated 1.02% whey protein concentrate and corn oil (3:1).	95
13	Emulsifying capacity and stability (m^2/g) for emulsions prepared with heated and unheated 1.52% whey protein concentrate and corn oil (3:1).	96
14	Emulsifying capacity and stability (m^2/g) for emulsions prepared with 0.51% whey protein concentrate at different pHs, heated at 80°C for 10 min and corn oil (3:1).	100
15	Emulsifying capacity and stability (m^2/g) for emulsions prepared with 0.51% whey protein concentrate at different lactose adding, heated at 80°C for 10 min and corn oil (3:1).	103
16	Emulsifying capacity (m^2/g) for emulsions prepared with 0.51% whey protein concentrate, heated at 80°C for 10 min and different ratios of corn oil, sun-flower oil and butter oil.	105
17	Emulsifying capacity and stability (m^2/g) for emulsions prepared with heated 0.51% whey protein concentrate at 80°C for 10 min and different ratios of corn oil .	108