

**QUALITY CHARACTERISTICS OF SOME FOOD
PRODUCTS CONTAINING DIFFERENT FAT-
REPLACERS**

By

EMAN EL- SAYED IBRAHIM YOUSEF

B.Sc. Agric. Sc. (Food Technology), Ain Shams University, 2006

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

MASTER OF SCIENCE

in

**Agricultural Science
(Food Science and Technology)**

**Department of Food Science
Faculty of Agriculture
Ain Shams University**

2010

Approval Sheet

**QUALITY CHARACTERISTICS OF SOME FOOD
PRODUCTS CONTAINING DIFFERENT FAT-
REPLACERS**

By

EMAN EL- SAYED IBRAHIM YOUSEF

B.Sc. Agric. Sc. (Food Technology), Ain Shams University, 2006

This thesis for M.Sc. degree has been approved by:

Prof. Dr. Ahmed Tawfeik El-Akal
Prof. of Food Technology, Faculty of Agriculture, Cairo
University

Prof. Dr. Yehia Abd El- Razek Heikal
Prof. Emeritus of Food Science and Technology, Faculty of
Agriculture, Ain Shams University

Prof. Dr. Ibrahim Rizk Sayed Ahmed
Prof. Emeritus of Food Science and Technology, Faculty of
Agriculture, Ain Shams University

Prof. Dr. Nagwa Mousa Hassen Rasmy
Prof. of Food Science and Technology, Faculty of
Agriculture, Ain Shams University

Date of Examination: ٢٠ / ١٠ / 2010

QUALITY CHARACTERISTICS OF SOME FOOD PRODUCTS CONTAINING DIFFERENT FAT-REPLACERS

By

EMAN EL- SAYED IBRAHIM YOUSEF

B.Sc. Agric. Sc. (Food Technology), Ain Shams University, 2006

Under the supervision of:

Prof. Dr. Nagwa Mousa Hassen Rasmy

Prof. of Food Science and Technology, Department of Food Science, Faculty of Agriculture, Ain Shams University (Principal Supervisor)

Prof. Dr. Ibrahim Rizk Sayed Ahmed

Prof. Emeritus of Food Science and Technology, Department of Food Science, Faculty of Agriculture, Ain Shams University

Dr. Hanan Mohamed Abdo Al - Sayed

Associate Prof. of Food Science and Technology, Department of Food Science, Faculty of Agriculture, Ain Shams University

ABSTRACT

Eman El-Sayed Ibrahim Yousef : Quality Characteristics of Some Products Containing Different Fat Replacers. Unpublished M.Sc. Thesis, Department Food Science , Faculty of Agriculture, Ain Shams University, 2010.

In this study , xanthan , flaxseed mucilage , carrageenan and defatted soybean flour were selected as fat replacers for developing reduced- fat products (i.e. mayonnaise and beef burger). In the first stage of experiment , the functional properties of the aqueous solutions of fat replacers were measured under different conditions. Xanthan showed the highest water and oil absorption capacity (WAC and OAC) among different selected fat replacers. A significant ($P \leq 0.05$) synergistic improvement in WAC appeared when two fat replacers were mixed . Addition of 0.2% divalent CaCl_2 resulted in increase of gel strength of carrageenan and enhanced the ability of flaxseed mucilage to form gel . On the other hand, adding xanthan, defatted soybean flour (fail to form gel) and flaxseed mucilage (formed weak gel) to carrageenan can not decrease the syneresis of gel in the presence of 0.2% CaCl_2 . Among the four selected fat replacers xanthan showed the most emulsion capacity (EC) and stability (ES) . A considerable enhancement in EC and ES was observed when two fat replacers was mixed. The flow curves of the selected fat replacers showed non-Newtonian behavior of pseudo- plastic type with yield stress and thixotropy. Values of consistency coefficient of xanthan solutions were higher than those of flaxseed mucilage , carrageenan and defatted soybean flour.

In the second stage of the study, the influence of partial substitution of fat in mayonnaise and beef burger formulations with (0.5 , 0.7 and 1%) fat replacers on physicochemical and sensorial properties of the reduced –

fat (Rf) food products were investigated . Reduced – fat mayonnaise formulated with carrageenan and defatted soybean flour were rejected by all panelists, since they fail to form oil-in-water emulsion. The result indicated that all Rf mayonnaises formulated with different levels of xanthan or flaxseed mucilage and their mixture had significantly ($P \leq 0.05$) lower fat and caloric values but higher water content and emulsion stability than their full- fat (Ff) mayonnaise samples . The caloric value was reduced by 48 , 34 and 61% in Rf mayonnaise with 0.7% xanthan , 1% flaxseed mucilage and 0.5% of both of them compared with the Ff (control). Full fat mayonnaise samples showed higher yield stress values than those of reduced fat mayonnaise samples supplemented with flaxseed mucilage , carrageenan and defatted soybean flour . However, incorporation of xanthan or its mixture with flaxseed mucilage in reduced fat mayonnaise samples produced a final product with rheological properties close to those of full- fat mayonnaise . From the obtained results it can be observed that use of xanthan or its mixture with flaxseed mucilage led to improvement of mayonnaise viscosity. Sensory evaluation demonstrated that Rf- mayonnaises formulated with 0.7% xanthan, 1% flaxseed mucilage and 0.5% of both of them were judged to be acceptable.

The moisture content of reduced – fat beef burger (Rf) formulated with 0.5 , 0.7 and 1% of selected fat replacers was inversely proportional to the fat content. The caloric value was reduced by 35.37% in Rf-beef burgers because of a lower level of added fat ($\approx 6\%$) , when compared to the normal fat (control) beef burger . Cooking yield , fat and water retention , shrinkage and diameter reduction were also improved in Rf-beef burger that had fat replacers incorporated when compared to control product. Fat had a highly significant effect on the hardness values of both raw and cooked beef burger . When fat level was reduced from about 20% to 6% in Rf- beef burger, hardness decreased in both raw and cooked burgers. Rf-beef burgers formulated with 1% xanthan , carrageenan ,

flaxseed mucilage or defatted soybean flour showed higher water holding capacity (WHC) than normal- fat beef burger sample(Nf)

Panel members gave reduced – fat beef burgers formulated with 0.5% carrageenan and flaxseed mucilage or 0.7% of xanthan and defatted soybean flour similar or higher ratings than the normal-fat sample for most attributes

In conclusion, partial substitution of fat with 0.7%xanthan , 1% flaxseed mucilage and 0.5% of both of them will produce reduced fat mayonnaise with a good consistency , high acceptability and storage stability but lower fat and caloric values than their full-fat counterpart . On the other hand , substitution of 70% of fat in beef burger formulation with 0.7% of selected fat replacers improved cooking characteristics , water holding capacity , hardness and sensory attributes of reduced –fat beef burger, within these 0.7% defatted soybean flour was better.

Key words:

Fat replacers – Xanthan – Flaxseed mucilage – Carrageenan – Defatted soybean flour – Functional properties –Mayonnaise- Emulsion stability - Low –fat beef burger.

ACKNOWLEDGEMENT

All praises are due to Allah, who blessed me with kind professors and colleagues, and gave me the support to finish this thesis.

I wish to extend my deepest appreciation and sincere gratitude to **Prof. Dr. Nagwa , M.H. Rasmy**, Professor of Food Science and Technology, Food Science Department, Faculty of Agriculture, Ain Shams University for the kind attention and greater help provided for the accomplishment of this work and for her efforts, supervising the research, writing the manuscript and encouraging me through this work. It is difficult to express in words my deep respect to her.

Thanks and gratefulness will not be enough to **Prof. Dr. I. R. Sayed Ahmed**, Professor of Food Science and Technology, Food Science Department, Faculty of Agriculture, Ain Shams University, for supervising this work, plentiful advice and endless efforts provided for me to complete this work.

Thanks and gratefulness to **Dr. Hanan. M.A.Al- Sayed** Associate Prof. of Food Science and Technology, Food Science Department, Faculty of Agriculture, Ain Shams University, for her true efforts throughout the lab work and writing the manuscript

I wish to find the words that can help me to express my gratefulness thanks, deepest gratitude and sincere appreciation to **Dr. Y. F. Kisik** Associate Prof. of Food Science and Technology, Food Science Department, Faculty of Agriculture, Ain Shams University, for his true efforts throughout the lab work.

I would like to thank all the staff members of Food Science and Technology Department at Ain Shams University

Thanks will not be enough to my parents and my brothers for their help and sincere support.

CONTENTS

	page
LIST OF TABLES	V
LIST OF FIGURES	VII
LIST OF ABBREVIATIONS	X
1. INTRODUCTION	1
2. REVIEW OF LITERATURE	6
2.1. Dietary fat in food and food products	6
2.1.1. Functional role of fat	7
2.1.2. Negative effect of fat on human health	8
2.1.2.1. Obesity (overweight)	9
2.1.2.2. Coronary heart diseases	11
2.1.2.3. Cholesterol	12
2.2. Fat replacers	14
2.2.1. Definition of fat replacer	15
2.2.2. Types of fat replacers	16
2.2.2.1. Carbohydrate-based fat replacers	19
2.2.2.2. Protein-based fat replacers	20
2.2.2.3. Fat-based fat replacers	21
2.3. Physicochemical properties of selected fat replacers	22
2.3.1. Xanthan gum	22
2.3.2. Carrageenan gum	24
2.3.3. Flaxseed mucilage	28
2.3.4. Defatted soybean flour	31
2.3.5. Polysaccharide and protein interaction	32
2.4. Application of fat replacers in some reduced fat food products	34
2.4.1. Reduced-fat mayonnaise	34
2.4.2. Reduced-fat meat products	38
3. MATERIALS AND METHODS	42

3.1. MATERIALS	42
3.1.1. Fat replacers	42
3.1.2. Mayonnaise ingredients	42
3.1.3. Beef-burger ingredients	42
3.2. METHODS	43
3.2.1. Technological treatments	43
3.2.1.1. Extraction of flaxseed mucilage	43
3.2.1.2. Reduced – fat mayonnaise manufacture	43
3.2.1.3. Reduced – fat beef burger manufacture	45
3.2.2. Analytical Methods	45
3.2.2.1. Physicochemical properties of selected fat Replacers	45
3.2.2.1.1 Proximate chemical composition of selected fat Replacers	47
3.2.2.1.2. Functional properties of selected fat replacers	47
3.2.2.1.2.1. Water absorption capacity	47
3.2.2.1.2.2. Oil absorption capacity	47
3.2.2.1.2.3. Gel formation	48
3.2.2.1.2.4. Solubility	48
3.2.2.1.2.5. Emulsifying properties	49
3.2.2.1.2.6. Thickening ability	49
3.2.2.2 Quality characteristics evaluation of reduced-fat mayonnaise	50
3.2.2.2.1 Proximate chemical analysis and caloric values	50
3.2.2.2.2. Rheological analysis	51
3.2.2.2.3. Color measurement	51
3.2.2.2.4. Sensory evaluation	51
3.2.2.2.5. Stability test	52
3.2.2.3 Quality characteristics evaluation of reduced-fat Beef-burger	52
3.2.2.3.1. Proximate chemical analysis and caloric values	52

3. 2.2.3.2. Cooking yield	52
3.2.2.3.3. Diameter reduction	53
3.2.2.3.4. Fat retention	53
3.2.2.3.5. Moisture retention	53
3.2.2.3.6. Shrinkage	54
3.2.2.3.7. Hardness	54
3.2.2.3.8. Water holding capacity and plasticity	54
3.2.2.3.9. Sensory evaluation	54
3.2..3. Statistical analysis	55
4. RESULTS AND DISCUSSION	56
4.1. Physico-chemical properties of some fat replacers	56
4.1.1. Proximate chemical composition of some fat replacers	56
4.2. Functional properties of fat replacers	57
4.2.1. Water and oil absorption capacity	57
4.2.2. Gel formation	60
4.2.3. Solubility	65
4.2.4. Emulsification properties	66
4.2.5. Rheological properties of flaxseed mucilage and other fat replacers	71
4.2.5.1. Flow curves	72
4.2.5.2. Dynamic viscosity	77
4.2.5.3 Rheological parameters	81
4.2.5.4. Yield stress and thixotropy of selected fat replacer solutions	85
4.3. Production of some reduced – fat food products	91
4.3.1. Reduced – fat mayonnaise	91
4.3.1.1. Chemical composition and caloric value of mayonnaise samples	92
4.3.1.2. Rheological properties of mayonnaise samples	95
4.3.1.2.1. Flow curves of mayonnaise samples	95

IV

4.3.1.2.2. Dynamic viscosity of mayonnaise samples	98
4.3.1.2.3. Rheological parameters of mayonnaise samples	98
4.3.1.3. Evaluation of color characteristics of mayonnaise samples	107
4.3.1.4. Sensory evaluation of mayonnaise samples	109
4.3.1.5. Mayonnaise emulsion stability	110
4.3.2. Reduced – fat beef burger	114
4.3.2.1. Chemical composition and caloric value of beef – burger samples	114
4.3.2.2. Cooking characteristics of beef –burger samples	118
4.3. 2.2.1 Cooking yield of beef burger samples	118
4.3.2.2.2 Diameter reduction of beef –burger samples	121
4.3.2.2. 3. Moisture and fat retention of beef –burger samples	123
4.3.2.2. 4. Shrinkage of beef –burger samples	125
4.3.2.3. Hardness of beef –burger samples	127
4.3.2.4. Water holding capacity and plasticity of beef burger- samples	130
4.3.2.5. Sensory evaluation of beef burger- samples	133
5. SUMMARY	136
6. REFERENCES	147
ARABIC SUMMARY	

LIST OF TABLES

No.	Title	Page
1	Examples of fat substitutes	17
2	Examples of fat mimetic	18
3	Suggested formula of full and reduced – fat mayonnaise samples	44
4	Suggested formula of normal and reduced – fat beef burger samples	46
5	Proximate chemical composition of selected fat replacers	56
6	Water and oil absorption capacities (WAC and WAO) and the relative hydrophilic / hydrophobic character (WOCl) of selected fat replacers	58
7	Gel formation of selected fat replacer and their mixture	61
8	Effect of 0.2% CaCl ₂ on gel formation of selected fat replacer and their mixture	64
9	The rheological parameters of selected fat replacers solutions and their mixtures	83
10	Constants of the relationship between selected fat replacers concentrations and apparent viscosity	85
11	Yield stress and thixotropy of selected fat replacer solutions	88
12	Proximate chemical analysis and caloric values of full fat (FF) and reduced fat (RF) mayonnaise samples	93
13	The rheological parameters of full fat (FF) and reduced fat (RF) mayonnaise samples	101

14	The color parameters of full fat (FF) and reduced fat (RF) mayonnaise samples	108
15	Sensory evaluation of fat (FF) and reduced fat (RF) mayonnaise samples	111
16	Proximate chemical analysis and caloric values of full fat (FF) and reduced fat (RF) beef burger samples	116- 117
17	Moisture and fat retention of normal(NF) and reduced-beef burger (RF) samples	124
18	Hardness (N/cm^2) of raw and cooked normal –fat (NF) and reduced fat (RF) beef burger samples	128
19	Water holding capacity (WHC) and plasticity (mm^2/g) of normal –fat (NF) and reduced fat (RF) beef burger samples	131
20	Sensory evaluation of normal- fat (FF) and reduced fat (RF) beef burger samples	135

LIST OF FIGURES

No	Title	Page
1	Solubility of selected fat replacers at different temperatures	65
2	Emulsification capacity (EC) of selected fat replacers at different concentration	67
3	Emulsification stability (ES) of selected fat replacers at different concentration	69
4	Emulsification capacity (EC) of mixture of two fat replacers at ratio (1:1w/w)	70
5	Emulsification stability (ES) of mixture of two fat replacers at ratio (1:1w/w)	70
6	Relationship between shear rate and shear stress for xanthan	74-75
7	Relationship between shear rate and shear stress for carrageenan	75
8	Relationship between shear rate and shear stress for flaxseed mucilage	76
9	Relationship between shear rate and shear stress for defatted soybean flour	76
10	Relationship between shear rate and shear stress for mixture of fat replacers at ratio (1:1)	77
11	The effect of shear rates on the dynamic viscosity of different concentration of xanthan at 25°c	79
12	The effect of shear rates on the dynamic viscosity of different concentration of carrageenan at 25°c	79
13	The effect of shear rates on the dynamic viscosity of different concentration of flaxseed mucilage at 25°c	80
14	The effect of shear rates on the dynamic viscosity of different concentration of defatted soybean at 25°c	80
15	The effect of shear rates on the dynamic viscosity of	81

VIII

	mixture of fat replacers at ratio (1:1) at 25°c	
16	The relationship between shear rate and shear stress for 1% solution of xanthan	89
17	The relationship between shear rate and shear stress for 1% solution of carrageenan	89
18	The relationship between shear rate and shear stress for 1% solution of flaxseed mucilage	90
19	The relationship between shear rate and shear stress for 1% solution of defatted soybean flour	90
20	The relationship between shear rate and shear stress for full and reduced fat mayonnaise samples	97
21	The relationship between shear rate and dynamic viscosity for full and reduced fat mayonnaise samples	99
22	The relationship between shear rate and shear stress for full fat mayonnaise samples	103
23	The relationship between shear rate and shear stress for reduced fat mayonnaise sample containing 0.5%xanthan	103
24	The relationship between shear rate and shear stress for reduced fat mayonnaise sample containing 0.7%xanthan	104
25	The relationship between shear rate and shear stress for reduced fat mayonnaise sample containing 1.0%xanthan	104
26	The relationship between shear rate and shear stress for reduced fat mayonnaise sample containing 0.5%flaxseed mucilage	105
27	The relationship between shear rate and shear stress for reduced fat mayonnaise sample containing 0.7%flaxseed mucilage	105
28	The relationship between shear rate and shear stress for reduced fat mayonnaise sample containing 1.0%flaxseed mucilage	106
29	The relationship between shear rate and shear stress for reduced fat mayonnaise sample containing a mixture of	106