

INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

Bell & Howell Information and Learning
300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA

UMI[®]
800-521-0600

PREVIEW

**DEVELOPMENT AND APPLICATION OF MULTICOMPONENT
EDIBLE FILMS**

by

Yi Wu

A DISSERTATION

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Doctor of Philosophy

Major: Interdepartmental Area of Nutrition

Under the Supervision of Professor Marilyn Schnepf

Lincoln, Nebraska

December, 1999

UMI Number: 9952697

UMI[®]

UMI Microform 9952697

Copyright 2000 by Bell & Howell Information and Learning Company.

All rights reserved. This microform edition is protected against
unauthorized copying under Title 17, United States Code.

Bell & Howell Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

DISSERTATION TITLE

Development and Application of Multicomponent Edible Films

BY

Yi Wu

SUPERVISORY COMMITTEE:

APPROVED

DATE

Marilynn Schnepf

Signature

Marilynn Schnepf

Typed Name

12/3/99

Susan Cuppett

Signature

Susan Cuppett

Typed Name

12/3/99

Curtis Weller

Signature

Curtis Weller

Typed Name

12/3/99

Nancy Betts

Signature

Nancy Betts

Typed Name

12/3/99

Fayrene Hamouz

Signature

Fayrene Hamouz

Typed Name

12/3/99

Signature

Typed Name



GRADUATE COLLEGE
UNIVERSITY OF NEBRASKA

DEVELOPMENT AND APPLICATION OF MULTICOMPONENT EDIBLE FILMS

Yi Wu, Ph.D.

University of Nebraska, 1999

Lay Abstract

Advisor: Marilyn Schnepf

Edible films and coatings based on carbohydrates, proteins and/or lipids were developed and tested for their effectiveness on controlling moisture loss and rancidity of precooked ground beef patties. Factors affecting instrumental analysis of rancidity in precooked meat, such as sample preparation method and sample amount were examined. The results were used in the follow-up edible film application studies. Wheat gluten (wheat protein), soy protein, carrageenan (a type of carbohydrate from edible seaweeds) and chitosan (a type of carbohydrate from shells of shellfish) films and coatings had different effects on maintaining the quality of precooked patties after 3-day refrigerated storage. All coatings were as effective as polyvinyl chloride film (a type of plastic film) in reducing patty moisture loss and more effective than films. Wheat gluten, carrageenan or soy protein coatings and carrageenan films were effective in inhibiting rancidity in patties with wheat gluten coating being the most effective. Incorporating fatty acids, especially 30-40% of palmitic acid and stearic acid, had a significant impact on moisture barrier properties and mechanical properties of soy protein films. Films were composed of soy protein and propyleneglycol alginate (PGA, a type of carbohydrate) showed improved moisture barrier properties and mechanical properties by adding PGA up to 10% and 17.5 %, respectively. The tortuous network

structure found in films containing starch, alginate (a type of carbohydrate from brown algae) and fatty acids may have contributed to the improved moisture barrier properties of these films, especially films with 30% fatty acids. Both soy protein-fatty acid films and starch-alginate-fatty acid films were heat sealable. During 6-day refrigerated storage, starch-alginate-stearic acid based films were effective in limiting moisture loss from precooked patties. Starch-alginate films and starch-alginate-stearic acid, that included food antioxidants, tocopherols, were effective in inhibiting rancidity in patties. All edible films, except for tocopherol-coated films, were generally not as effective as polyester bags (plastic bags) in controlling moisture loss and the development of rancidity.

PREVIEW

DEVELOPMENT AND APPLICATION OF MULTICOMPONENT EDIBLE FILMS

Yi Wu, Ph.D.

University of Nebraska, 1999

Advisor: Marilynn Schnepf

Edible films and coatings based on polysaccharides, proteins and/or lipids were developed and tested for their effectiveness in controlling moisture loss and lipid oxidation of precooked ground beef patties. Factors affecting gas chromatographic analysis of lipid oxidation in precooked meat, such as sample preparation methods, equilibration times and sample phase fraction, were examined. They were controlled and used in the follow-up edible film application studies. Wheat gluten, soy protein, carrageenan and chitosan films and coatings had different effects on maintaining the quality of precooked patties after 3-day storage at 4°C. All coatings were as effective ($P < 0.05$) as polyvinyl chloride film in reducing patty moisture loss and more effective than films. Coating with wheat gluten, carrageenan or soy protein and wrapping with carrageenan films were effective ($P < 0.05$) in lowering patty thiobarbituric acid reactive substance values (TBARS) and hexanal values with wheat gluten coating being the most effective ($P < 0.05$), which resulted in about 28% and 48% reduction in TBARS and hexanal, respectively. Incorporating fatty acids, especially 30-40% of palmitic acid and/or stearic acid, had a significant ($P < 0.05$) impact on water barrier properties and mechanical properties of soy protein films. Composite films of soy protein and propyleneglycol alginate showed improved ($P < 0.05$) moisture barrier properties and

mechanical properties by adding propyleneglycol alginate up to 10% and 17.5 %, respectively.

The tortuous network structure observed in starch-alginate-fatty acid films using scanning electron microscopy may have contributed to the improved moisture barrier properties of these films, especially in films with 30% fatty acids. During 6-day storage at 4°C, starch-alginate-stearic acid based films were effective ($P < 0.05$) in limiting moisture loss from precooked patties. Tocopherol treated starch-alginate films and starch-alginate-stearic acid films were effective ($P < 0.05$) in inhibiting the lipid oxidation in patties by lowering TBARS and other oxidation products. All edible films, except for tocopherol-coated films, were generally not as effective ($P > 0.05$) as polyester vacuum bags in controlling moisture loss and lipid oxidation, and their effects were storage time dependable.

PREVIEW

Dedicated to

my daughter, Natalie, for her love

*and wish her "qing chu yu lan er sheng yu lan (green arises from
blue but is superior to blue)"*

and to my husband, parents, sister and brother for their love

PREVIEW

ACKNOWLEDGMENTS

This is a very exciting moment as another journey in my life is coming to an end. No words can really help me to express my deep and sincere appreciation and gratitude to the many people who supported and assisted me in accomplishing this journey that was full of challenges.

I would like to express my sincere appreciation to my advisor, Dr. Marilyn Schnepf, for her valuable guidance and support during my graduate program. Her faith in my abilities and her consistent encouragements allowed me to rise to many challenges and to achieve many seemingly impossible goals for my professional career and life. The many moments she shared her insights with me about the meaning of research, education and life will always inspire me and stay with me.

I am also greatly indebted to Dr. Fayrene Hamouz, Dr. Curtis Weller, Dr. Susan Cuppett and Dr. Nancy Betts for serving as members of my supervisory committee. Their support, advice and encouragements have provided me with the freedom to discover and study my dissertation project. Their influence on my professional development and my life, and the friendship developed through the years shall never be forgotten.

Sincere gratitude is extended to Dr. John-Wang Rhim, a visiting professor in Dr. Weller's laboratory, for his support, suggestions and assistance during my dissertation studies. It has truly been a pleasure to work with him.

Special thanks go out to Dr. Aristippos Gennadios for his teaching in determination of water vapor permeability of edible films, and his advice and encouragements for my career development.

The assistance I received from Dr. Kent Eskridge and Dr. Anne Parkhurst in the

Department of Biometry is gratefully acknowledged. The assistance provided by Tom Bargar in the Department of Veterinary and Biomedical Science in performing scanning electron microscopic examination and the development of photomicrographs, and by Dayna Dughman in the Industrial Agricultural Products Center in conducting tensile strength and elongation testing on edible films are also highly appreciated. The completion of this dissertation would not be possible without these people's valuable suggestions and contributions.

Sincere appreciation goes to David Giraud for his technical assistance in the analysis of tocopherols and especially, for his kindness, encouragements and friendship. Without his valuable help, my family and I would not be able to solve many daily life puzzles and English puzzles that we have encountered during the years in Nebraska.

A huge thanks is extended to all members of the Department of Nutritional Science and Dietetics. Special thanks also goes to Dr. Tim Carr, Dr. Julie Albrecht, Dr. Beverly Benes, Dr. Judy Driskell, Dr. Wanda Koszewski, Donna Hahn, Julie Block, Jeannie Pittam, Lori Rausch, Cindy Stuefer-Powell, Cindy Hayes, Ahmad Sulaeman and Carol Ray. I have enjoyed the many moments of talking and working with you and thanks for all of the little things that made a big difference.

A very special thank you is expressed to Dr. Jerry Maranville in the Department of Agronomy for his role in bringing me to this new world and to Nebraska for my study. The mid-night warm welcome given by Dr. Jerry Maranville and Mrs. Donna Maranville at the Lincoln Municipal Airport when I first arrived in this country and the time I spent with them are always remembered with gratitude.

Sincere thanks also go out to Dr. Stanley Jensen in the Department of Plant Pathology for providing me the opportunity to work with him and for his friendship.

I would like to extend my appreciation to all my friends here and in China for their consistent encouragements and forever friendship.

I wish to express my heartfelt appreciation to my parents for inspiring me with willingness and courage to learn, for all kinds of supports they have given me throughout my entire life and for giving me the confidence to strive for only the best in life. And to my sister and brother, for their love and consistent supports.

Finally, I wish to express my deepest love and heartfelt appreciation to my baby daughter, Natalie, and my husband, Shengming, for their love, sacrifices, patience, understanding and encouragements during the course of my graduate journey. When challenges were greatest, they were always behind me. Without their loving support along the way, I could not have completed this journey!

And dear Natalie, your Dr. Mom can spend more time with you along your growing up journey now.

Yi

PREFACE

Research in the development and application of edible films and coatings has recently intensified. This growing interest in the concept of edible films and coatings is driven by the increased consumer demand for high quality, long shelf-life and ready-to-eat foods, environmental consciousness for disposal of nonrenewable food packaging materials, and the opportunities for creating new market outlets for both traditional and novel agricultural crops which are the sources of the desired film-forming ingredients. One of the most useful functions of edible films and coatings is their ability to act as barriers, either to gas, solute or moisture. Besides their barrier properties, edible films and coatings can function as carriers for food additives such as antioxidants, antimicrobial agents and nutrients.

Edible films and coatings have been developed from polysaccharide, protein and lipid materials. Such films along, in combination or with other components have exhibited the promise for innovative uses as food protective materials in different type of foods. However, the application of edible films and coatings including multicomponent edible films on processed foods, especially those characterized by a high moisture content such as precooked meat products, is an area that has received little attention.

The objective of this dissertation was to 1) determine the effectiveness of several edible films and coatings on moisture loss and lipid oxidation from precooked ground beef patties, 2) develop soy protein-based and starch-alginate-based multicomponent edible films, and 3) determine the effectiveness of starch-alginate-based multicomponent edible films as barriers and/or antioxidant carriers on moisture loss and lipid oxidation from precooked ground beef patties.

This dissertation consists of eight different chapters.

The first chapter is an overview on the research of the development and application of multicomponent edible films.

Each of the next six chapters is written as an individual research article complete with introduction, materials and methods, results and discussion, and references. The first research article reports a methodology study on static headspace gas chromatographic analysis of lipid oxidation of precooked meat products. The method developed was used in studies described in the second and sixth research articles. The second research article demonstrates how coatings and films developed from wheat gluten, soy protein, carrageenan and chitosan could be used as moisture and/or oxygen barriers to maintain quality of precooked ground beef patties. To improve moisture barrier properties, multicomponent films were prepared and characterized using soy protein-fatty acids and soy protein-propyleneglycol alginate as discussed in the third and fourth research article, respectively. The fifth research article presents observations on moisture barrier properties and microstructures of multicomponent films of starch-alginate-fatty acids. The last article describes the effectiveness of the previously developed starch-alginate-stearic acid film as a moisture and oxygen barrier and as an antioxidant carrier on maintaining quality of precooked ground beef patties.

A summary of all dissertation studies and recommendations for future research are given at the end of this dissertation.

TABLE OF CONTENTS

CHAPTER 1. DEVELOPMENT AND APPLICATION OF MULTICOMPONENT EDIBLE FILMS AND COATINGS: A REVIEW.....	1
Introduction	2
Barrier Properties of Edible Films	4
Polysaccharide-lipid Edible Films	6
Water Barrier Properties	6
Factors Affecting Water Barrier Properties	14
Surfactants	14
RH	14
Temperature	16
Oxygen Barrier Properties	17
Factors Affecting Oxygen Barrier Properties.....	18
RH	18
Temperature	18
Solute Barrier Properties	18
Factors Affecting Water Barrier Properties	20
RH	20
Temperature	20
Application of Polysaccharide-lipid films	21
Protein-lipid Edible Films	23
Water Barrier Properties	24
Gelatin and casein-based Films	24
Wheat Gluten-based Films	25
Soy Protein-based Films	28
Corn Zein-based Films	28
Whey Protein-based Films	29
Oxygen Barrier Properties	32
Factors Affecting Barrier Properties.....	33
RH	33
Application of Protein-lipid films	34
Other Types of Multicomponent Edible Films	35
Barrier Properties	36
Application of other types of Multicomponent Edible Films	38
Summary	39
References	40
 CHAPTER 2. FACTORS AFFECTING STATIC HEADSPACE-GAS CHROMATOGRAPHIC ANALYSIS OF LIPID OXIDATION IN PRECOOKED MEAT	 62
Abstract	63
Introduction	63

Materials and Methods	65
Meat Sample Preparation	65
HS-GC analysis	65
BHT oil solution preparation	67
Experiment I	67
Experiment II	67
Experiment III	68
Statistical Analysis	68
Results and Discussion	69
Experiment I	69
Experiment II	70
Experiment III	72
Conclusions	75
References	76

CHAPTER 3. MOISTURE LOSS AND LIPID OXIDATION FOR PRECOOKED GROUND BEEF PATTIES STORED IN PROTEIN AND POLYSACCHARIDE EDIBLE/BIODEGRADABLE FILMS AND COATINGS 86

Abstract	87
Introduction	87
Materials and Methods	89
Materials	89
Preparation of Coatings and Films	89
Meat Sample Preparation and Packaging Application	91
Apparent Characteristics of Coatings and Films	91
Relative Moisture Loss (RML)	91
2-Thiobarbituric Acid (TBA) Test	91
Headspace Gas Chromatographic (HS-GC) Analysis	92
Statistical Analysis	92
Results and Discussion	93
Apparent characteristics of coatings and films	93
Relative Moisture Loss	93
TBARS Values	95
Hexanal Values	98
Conclusions	99
References	100

CHAPTER 4. PHYSICAL CHARACTERISTICS OF EMULSIFIED SOY PROTEIN-FATTY ACID COMPOSITE FILMS 109

Abstract	110
Introduction	110
Materials and Methods	112

Materials	112
Preparation of Films	112
Thickness	113
Conditioning	114
Apparent Characteristics of Films	114
Color	114
Tensile Strength and Percentage Elongation at Break	115
Water Vapor Permeability	115
Water Solubility	116
Statistical Analysis	117
Results and Discussion	117
Apparent Characteristics of Films	117
Color	118
Tensile Strength and Elongation	118
Water Vapor Permeability	120
Water Solubility	123
Conclusions	124
References	125

CHAPTER 5. PHYSICAL CHARACTERISTICS OF A COMPOSITE FILM OF SOY PROTEIN ISOLATED AND PROPYLENEGLYCOL ALGINATE

135

Abstract	136
Introduction	136
Materials and Methods	138
Materials	138
Preparation of Soy Films	138
Thickness	139
Conditioning	139
Color	140
Tensile Strength and Percentage Elongation at Break	140
Water Vapor Permeability	141
Water Solubility	142
Statistical Analysis	142
Results and Discussion	143
Color	143
Tensile Strength and Elongation	144
Water Vapor Permeability	145
Moisture Content and Water Solubility	145
Conclusions	146
References	147

CHAPTER 6. WATER VAPOR PERMEABILITY, WATER SOLUBILITY AND MICROSTRUCTURE OF EMULSIFIED STARCH ALGINATE-FATTY ACID COMPOSITE FILMS

157

Abstract	158
Introduction	158
Materials and Methods	161
Materials	161
Preparation of Films	161
Thickness	161
Conditioning	161
Water Vapor Permeability	161
Water Solubility	162
Heat Sealability	163
Scanning Electron Microscopy (SEM)	163
Statistical Analysis	164
Results and Discussion	164
Water Vapor Permeability	164
Water Solubility	166
Heat Sealability	167
Scanning Electron Microscopy (SEM)	168
Conclusions	169
References	171

CHAPTER 7. MOISTURE LOSS AND LIPID OXIDATION FOR PRECOOKED GROUND BEEF PATTIES PACKAGED IN EDIBLE STARCH-ALGINATE BASED COMPOSITE FILMS 177

Abstract	178
Introduction	178
Materials and Methods	181
Materials	181
Preparation of Film Packaging	182
Meat Sample Preparation and Packaging Application	183
Patty Weight Loss	184
2-Thiobarbituric Acid (TBA) Test	184
Headspace Gas Chromatographic (HS-GC) Analysis	184
Experimental Design and Statistical Analysis	185
Results and Discussion	185
Patty Weight Loss and Relative Moisture Loss	185
TBARS Values	188
Volatile Analysis	190
Conclusions	194
References	195

CHAPTER 8. A SUMMERY 207

LIST OF TABLES

Table 1.1	Permeability of synthetic edible films	52
Table 1.2	Water vapor permeability of polysaccharide-lipid multicomponent edible films	53
Table 1.3	Oxygen permeability of multicomponent edible films	56
Table 1.4	Water vapor permeability of protein-lipid multicomponent edible films	58
Table 1.5	Water vapor permeability of other types of multicomponent edible films	60
Table 2.1	Comparison of peak area variation of selected volatile compounds from cooked ground beef patties when different sample preparation methods were used in Experiment II.	84
Table 2.2	Effect of sample blending time/sample particle size and sample phase fraction (Φ s) on the peak area of selected volatiles per gram sample	85
Table 3.1	Apparent characteristics of coatings and films of wheat gluten (WG), soy protein (SP), carrageenan (CA) and chitosan (CH) on precooked beef patties at the beginning and after 3-day storage	105
Table 4.1	Apparent characteristics and heat sealability of soy protein-fatty acid composite films	129
Table 5.1	Film thickness and hunter color values (L, a and b) of soy protein isolate (SPI) films with various levels of incorporated propyleneglycol alginate (PGA)	151
Table 6.1	Water vapor permeability (WVP) and water solubility (WS) of starch-alginate films with lauric acid (LA), palmitic acid (PA), or stearic acid (SA)	175

LIST OF FIGURES

Figure 1.1	Schematic representation of the cross-section of films	49
Figure 1.2	Representation of interface water-oil: (A) electronic repulsion; (B) steric repulsion	50
Figure 1.3	Effect of coating composition on water loss of a cut apple	51
Figure 2.1	Sample equilibration time for pentane when two different sample preparation methods were used in Experiment I.	79
Figure 2.2	Sample equilibration time for hexanal when two different sample preparation methods were used in Experiment I.	80
Figure 2.3	Sample equilibration time for total when two different sample preparation methods were used in Experiment I.	81
Figure 2.4	Effect of sample blending time/sample particle size and sample phase fraction on the peak areas of selected volatile compounds from cooked ground beef patties in Experiment III.	82
Figure 2.5	Effect of sample blending time/sample particle size and sample phase fraction on the peak areas variation of selected volatile compounds from cooked ground beef patties in Experiment III.	89
Figure 3.1	Relative moisture loss of precooked beef patties not packaged (A), packaged in polyvinyl chloride (B), and packaged in edible coatings and films of wheat gluten (WG), soy protein (SP), carrageenan (CA) or chitosan (CH) after 3 days of storage at 4°C	106
Figure 3.2	Values of thiobarbituric acid-reactive substances (TBARS) of precooked beef patties not packaged (A), packaged in polyvinyl chloride (B), and packaged in edible coatings and films of wheat gluten (WG), soy protein (SP), carrageenan (CA) or chitosan (CH) after 3 days of storage at 4°C	107
Figure 3.3	Hexanal values of precooked beef patties not packaged (A), packaged in polyvinyl chloride (B), and packaged in edible coatings and films of wheat gluten (WG), soy protein (SP), carrageenan (CA) or chitosan (CH) after 3 days of storage at 4°C	108

Figure 4.1	Change of color values of soy protein isolate-fatty acid composite films as a function of fatty acid concentration	130
Figure 4.2	Change of tensile strength of soy protein isolate-fatty acid composite films as a function of fatty acid concentration	131
Figure 4.3	Change of elongation at break of soy protein isolate-fatty acid composite films as a function of fatty acid concentration	132
Figure 4.4	Change of water vapor permeability of soy protein isolate-fatty acid composite films as a function of fatty acid concentration	133
Figure 4.5	Change of water solubility of soy protein isolate-fatty acid composite films as a function of fatty acid concentration	134
Figure 5.1	Change of color values of soy protein isolate-propyleneglycol alginate composite films as related to propyleneglycol alginate content	152
Figure 5.2	Change of tensile strength of soy protein isolate-propyleneglycol alginate composite films as related to propyleneglycol alginate content	153
Figure 5.3	Change of elongation at break of soy protein isolate-propyleneglycol alginate composite films as related to propyleneglycol alginate content	154
Figure 5.4	Change of water vapor permeability of soy protein isolate-propyleneglycol alginate composite films as related to propyleneglycol alginate content	155
Figure 5.5	Change of moisture content and water solubility of soy protein isolate-propyleneglycol alginate composite films as related to propyleneglycol alginate content	156
Figure 6.1	Scanning electron microscopy photomicrographs of starch-alginate-fatty acid films (fatty acid = 30% starch-alginate, w/w)	190
Figure 7.1	Patty weight loss of precooked beef patties not packaged (C-A), packaged in polyester vacuum bags (C-B) and packaged in edible films of starch-alginate (SA), starch-alginate-stearic acid (SAS), SA-tocopherol (SAT), SAS-tocopherol (SAST), tocopherol coated SA (SATC) and tocopherol coated SAS (SASTC) during 6-day storage at 4°C	200

- Figure 7.2 Relative moisture loss of precooked beef patties not packaged (C-A), packaged in polyester vacuum bags (C-B) and packaged in edible films of starch-alginate (SA), starch-alginate-stearic acid (SAS), SA-tocopherol (SAT), SAS-tocopherol (SAST), tocopherol coated SA (SATC) and tocopherol coated SAS (SASTC) during 6-day storage at 4°C 201
- Figure 7.3 Values of thiobarbituric acid-reactive substances of precooked beef patties not packaged (C-A), packaged in polyester vacuum bags (C-B) and packaged in edible films of starch-alginate (SA), starch-alginate-stearic acid (SAS), SA-tocopherol (SAT), SAS-tocopherol (SAST), tocopherol coated SA (SATC) and tocopherol coated SAS (SASTC) during 6-day storage at 4°C 202
- Figure 7.4 Values of hexanal of precooked beef patties not packaged (C-A), packaged in polyester vacuum bags (C-B) and packaged in edible films of starch-alginate (SA), starch-alginate-stearic acid (SAS), SA-tocopherol (SAT), SAS-tocopherol (SAST), tocopherol coated SA (SATC) and tocopherol coated SAS (SASTC) during 6-day storage at 4°C 203
- Figure 7.5 Values of pentane of precooked beef patties not packaged (C-A), packaged in polyester vacuum bags (C-B) and packaged in edible films of starch-alginate (SA), starch-alginate-stearic acid (SAS), SA-tocopherol (SAT), SAS-tocopherol (SAST), tocopherol coated SA (SATC) and tocopherol coated SAS (SASTC) during 6-day storage at 4°C 204
- Figure 7.6 Values of total of precooked beef patties not packaged (C-A), packaged in polyester vacuum bags (C-B) and packaged in edible films of starch-alginate (SA), starch-alginate-stearic acid (SAS), SA-tocopherol (SAT), SAS-tocopherol (SAST), tocopherol coated SA (SATC) and tocopherol coated SAS (SASTC) during 6-day storage at 4°C 205

CHAPTER 1

DEVELOPMENT AND APPLICATION OF MULTICOMPONENT EDIBLE FILMS AND COATINGS: A REVIEW

This review is to be submitted to:

Advances in Food and Nutrition Research.

PREVIEW