PROCESSING AND STORAGE CHARACTERISTICS OF SOUS VIDE IRANIAN BEEF STEW

NAGHMEH TAHERI HERAVI

FK 2009 49
PROCESSING AND STORAGE CHARACTERISTICS OF SOUS VIDE IRANIAN BEEF STEW

By

NAGHMEH TAHERI HERAVI

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the requirement for the Degree of Master

May 2008
ESPECIALLY DEDICATED TO MY BELOVED FAMILY
WHO HAD GIVEN ME THE FULL SUPPORT
Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

PROCESSING AND STORAGE CHARACTERISTICS OF SOUS VIDE IRANIAN BEEF STEW

By

NAGHMEH TAHERI HERAVI

May 2009

Chairman: Professor Russly Abdul Rahman, PhD

Faculty: Engineering

Khorak-e-Mahicheh (muscle beef/lamb stew) is one of the favorite Iranian dishes which requires long time and carefully controlled cooking. Development of the product with improved storage stability and ease of preparation would enhance its acceptance for consumption. Sous vide system which is the minimal thermal process and subsequent chilled storage of vacuum packaged foods (raw or par-cooked), appears as an interesting alternative to produce ready to eat dish and is considered to offer enhanced product quality and extended shelf life. Preparation, storage studies and quality attributes of sous vide Khorak-e-Mahicheh was the aim of this study. The experimental design was established on factorial structure (3×7). The factors were storage time and method of processing. Significant level was 5% (p<0.05). In traditional recipe, beef muscle slices were fried with chopped onion and garlic for few minutes and cooked over moderate heat. In par-cooking and raw-cooking process, muscle slices were fried with chopped onion and garlic (in par-cooking
process, muscle slices were cooked in a domestic pressure cooker (103 kPa) for 15 minutes, before frying), vacuum packaged and then, cooked in a water bath at 95 °C, for sufficient cooking time. Samples were cooled down immediately after cooking to 4°C. Heat penetration and cooling phase data were monitored by inserting the thermocouples into geometric center of the vacuumed samples. Adequate numbers of samples were stored at 4°C for subsequent studies. Raw-cooked sous vide and par-cooked sous vide were stable from any microbiological spoilage during 6 weeks of storage. In traditional cooking after fifth week, number of mesophiles increased (2-3 log colony-forming unit/grams). In all cooking methods, Bacillus cereus and psychrotrophs were not detected during storage time. Sufficient cooking times (sensory-based) which were found via shear force values were markedly higher than calculated cooking time (based on 6 and 13 log reduction of Clostridium botulinum and Streptococcus faecium, respectively). Cooking methods had significant (p<0.05) effect moisture content, water holding capacity, cooking weight loss, instrumental color and rancidity, but there was no significant effect on pH and water activity of Khorak-e-Mahicheh. The results of sensory evaluation showed that cooking methods and storage time had no significant effect on aroma, color, tenderness, juiciness and overall acceptance. Texture Profile Analysis illustrated that cooking methods and storage time affected the texture quality attributes (hardness, springiness, chewiness, adhesiveness, gumminess and cohesiveness) significantly (p<0.05). Storage time had significant effect on rancidity, water holding capacity, moisture content and lightness of the product. It was concluded that sous vide process could be a fresh-like and convenient alternative to traditionally cooked Khorak-e-Mahicheh since it offered higher quality, reliable safety and extended durability.
Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PEMPROSESAN DAN CIRI PENYIMPANAN STEW SOUS VIDE DAGING IRAN

Oleh

NAGHMEH TAHERI HERAVI

Mei 2009

Pengerusi: Profesor Russly Abdul Rahman, PhD

Fakulti: Kejuruteraan

Khorak-e-Mahicheh merupakan makanan kegemaran rakyat Iran yang memerlukan masa pemasakan yang lama serta terkawal. Penghasilan produk seperti ini akan meningkatkan stabiliti penyimpanan dan penyediaan serta membantu dalam penerimaan ke atas penggunaan di rumah dan institusi perkhidmatan makanan. Sistem sous vide adalah satu sistem pemprosesan yang melibatkan penggunaan terma yang minima untuk makanan mentah atau pra-masak yang divakumkan dalam bekas dan didinginkan dengan secepat mungkin. Oleh yang demikian, sistem sous vide dilihat sebagai alternatif yang menarik untuk menghasilkan produk daging mudah dimakan serta berkualiti. Tujuan kajian ini adalah untuk mengkaji penyediaan, penyimpanan serta kualiti sous vide Khorak-e-Mahicheh. Kajian faktorial berasaskan kepada struktur (3×7) telah digunkan untuk tujuan penyelidikan ini. Faktor-faktor yang terlibat dalam kajian ini termasuklah waktu penyimpanan (0, 7, 14, 21, 28, 35 dan 42 hari) dan cara pemprosesan (kebiasaan memasak, sous vide pra-masak dan

v
sous vide masak-mentah). Tahap kepentingan adalah 5% (p<0.05). Dalam resepi tradisional, kepingan daging digoreng bersama bawang merah and bawang putin yang terlah dihiris selama beberapa minit. Proses pra-masak kepingan daging dimasak menggunakan periuk tekanan (103 kPa) yang mengambil masa selama 15 minit, pek dirakum dan dimasak menggunakan proses ‘water bath’ pada suhu 95 °C sehingga cukup masak. Kemudian, kesemua sampel disimpan didalam bilik sejuk beku pada 4 °C. Proses penerapan haba and penyejukbekuan ini dipantauan menggunakan ‘thermocouples’ yang dimasukkan ke dalam pek yang telah divakumkan. Sous vide masak-mentah dan sous vide pra-masak berada dalam keadaan stabil dan tidak mengalami kerosakan mikroorganisma semasa proses penyimpanan selama 6 minggu. Bagi pemasakan secara tradisional, jumlah mikroorganisma mesophilik didapati bertambah (2-3 log colony-forming unit/gram) pada minggu kelima. Selama waktu penyimpanan, Bacillus cereus dan jumlah psychrotrophics tidak dapat dikesan untuk semua cara pemasakan. Berdasarkan data daya ricih, masa pemasakan yang mencukupi (berdasarkan sensori) didapati lebih tinggi berbanding masa pemasakan kiraan (masing-masing berdasarkan 6 dan 13 log reduksi Clostridium botulinum dan Streptococcus faecium). Cara memasak didapati mempunyai kesan yang signifikan (p<0.05) terhadap kandungan lembap, kapasiti menampung air, kehilangan jirim memasak, warna dan ketengikan, tetapi, tidak mempunyai kesan signifikan (p<0.05) terhadap pH dan aktiviti air Khorak-e-Mahicheh. Hasil kajian dari penilaian deria menunjukkan bahawa cara memasak tidak memberi kesan yang signifikan terhadap aroma, warna, keliatan, ‘juiciness’ dan penerimaan secara keseluruhannya. Profil analisis tekstur menunjukkan bahawa cara memasak dan waktu penyimpanan mempengaruhi kualiti dan ciri-ciri tekstur (kekerasan, ‘springiness’, ‘chewiness’, ‘adhesiveness’, ‘gumminess’ dan vi
‘cohesiveness’) secara signifikan (p<0.05). Manakala, waktu penyimpanan didapati memberi kesan yang signifikan terhadap ketengikan, kapasiti menampung air, kandungan lembapan dan keringan produk. Kesimpulannya, proses sous vide adalah sesuai sebagai alternatif untuk masakan tradisional Khorak-e-Mahicheh dimana produk akhir adalah lebih berkualiti, selamat dan tahan lama.
AKNOWLEDGEMENTS

I pray to Almighty ALLAH Subhanahu wa Ta’ala who give me the thoughts, the will, and guided me to complete this work. I pray that ALLAH will bless this work and make it useful for mankind, and that He will forgive us.

My sincere and deepest gratitude is offered to Professor Dr Russly Abdul Rahman, the chairman of my supervisory committee for his guidance, encouragement, patience and continuous follow up during the course of this study. My appreciation and gratitude is also extended to members of my supervisory committee, for their advice, punctuate comments and support.

My gratitude is also due to all the staff of the Faculty of Engineering and Faculty of Food Science and Technology, UPM for their cooperation.

Finally, I must express my deepest gratitude to my parents who continuously encourage me, support me and present me the most beautiful world.
I certify that an Examination Committee met on 28th 2009 to conduct the final examination of Naghmeh Taheri Heravi on her Master thesis entitled “PROCESSING AND STORAGE CHARACTERISTICS OF SOUS VIDE IRANIAN MUSCLE BEEF STEW” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The committee recommends that the candidate be awarded the relevant degree of Master of Science.

Members of Examination Committee were as follows:

JOHARI BIN ENDAN, PhD
Associated Professor
Department of Process and Food Engineering
Faculty of Engineering
Universiti Putra Malaysia
Chairman

LING TAU CHUAN
Associated Professor
Department of Process and Food Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

MOHD NORDIN BIN IBRAHIM
Associated Professor
Department of Process and Food Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

AZHAR MAT EASA
Associated Professor
School of Industrial Technology
Universiti Sains Malaysia
(External Examiner)

BUJANG KIM HUAT, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date
This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of Supervisory Committee were as follows:

**Russly Abd. Rahman, PhD**  
Professor,  
Department of Process and Food Engineering  
Faculty of Engineering  
Universiti Putra Malaysia  
(Chairman)

**Jamilah Bakar, PhD**  
Professor,  
Department of Food Technology  
Faculty of Food Science and Technology  
Universiti Putra Malaysia  
(Member)

**Chin Nyuk Ling, PhD**  
Lecturer  
Department of Process and Food Engineering  
Faculty of Engineering  
Universiti Putra Malaysia  
(Member)

---

**HASSANA MOHD. GHAZALI, PhD**  
Professor and Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date: 9 July 2009
DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not or concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

____________________________
NAGHMEH TAHERI HERAVI
Date: 16 June 2009
TABLE OF CONTENTS

ABSTRACT iii
ABSTRAK vi
ACKNOWLEDGEMENTS ix
APPROVAL x
DECLARATION xii
LIST OF TABLES xvi
LIST OF FIGURES xviii
LIST OF ABBREVIATIONS xx

CHAPTER

1 INTRODUCTION 1

2 LITERATURE REVIEW 4
  2.1 Chilled Foods 4
  2.2 Vacuum Packaging 8
  2.3 Sous vide 10
    2.3.1 Definition 10
    2.3.2 Principles 13
    2.3.3 Sous vide Products 14
    2.3.4 Meat Base Sous vide Products 15
  2.4...Iranian Muscle Beef Stew (Khorak-e-Mahicheh) 20
  2.5 Process Design/Thermal processing 21
    2.5.1 Heat Transfer 22
    2.5.2 Pasteurization 22
  2.6 Thermal Process Calculations 28
    2.6.1 General method 29
    2.6.2 Heat Penetration Test and Processing Parameters 30
  2.7 Rapid Cooling 31
  2.8 Chilled Storage 33
  2.9 Reheating 34
  2.10 Shelf Life and Quality Attribute 35
    2.10.1 Stability and Shelf Life 35
    2.10.2 Cooking Loss 37
    2.10.3 Rancidity 38
    2.10.4 Texture 40
    2.10.5 Warmed Over Flavor 44
    2.10.6 Water Holding Capacity 45
  2.11 Food Safety Aspects of Sous vide 46
    2.11.1 Food Spoilage 47
    2.11.2 Temperature abuse 48
    2.11.3 Microbial Concerns of Sous vide Products 50
    2.11.4 Psychrothrophs 54
    2.11.5 Mesophiles 55
    2.11.6 Factors Which Ensure Safety 56
  2.12 Guidelines and legislations 58

xii
3 MATERIALS AND METHODS

3.1 Materials 63
3.2 Experimental Design 63
3.3 Sample Preparation 64
    3.3.1 Methods of Khorak-e-Mahicheh Preparation 65
3.4 Determination of Cooking Time 71
3.5 Thermal Processing 72
    3.5.1 Determination of Heat Penetration Parameters for Sous Vide Khorak-e-Mahicheh 72
    3.5.2 Calculation of Pasteurization Value 73
    3.5.3 Determination of Pasteurization Time 74
3.6 Physico-Chemical Analysis 75
    3.6.1 Texture Profile Analysis 75
    3.6.2 Water Activity (aw) 77
    3.6.3 Color 77
    3.6.4 Moisture Content 78
    3.6.5 Cooking Weight Loss 78
    3.6.6 Water Holding Capacity (WHC) 78
    3.6.7 pH 79
    3.6.8 Thiobarbituric Acid (TBA) 79
3.7 Microbial Analysis 80
    3.7.1 Total Psychrotrophs 81
    3.7.2 Anaerobic Psychrotrophs 81
    3.7.3 Total Mosophiles 81
    3.7.4 Anaerobic Mesophiles 82
    3.7.5 Bacillus cereus 82
3.8 Sensory evaluation 82
3.9 Statistical Analysis 83

4 RESULTS AND DISCUSSION 85
4.1 Thermal Processing 85
    4.1.1 Determination of Heat Penetration Parameters for Sous vide Khorak-e-Mahicheh 85
    4.1.2 Calculation of Pasteurization Value 87
    4.1.3 Determination of Sufficient Cooking time 92
4.2 Physico-Chemical Analysis 92
    4.2.1 Texture Profile Analysis 92
    4.2.2 Water Activity (aw) 106
    4.2.3 Color 110
    4.2.4 Moisture Content 115
    4.2.5 Cooking Weight Loss 118
    4.2.6 Water Holding Capacity (WHC) 119
    4.2.7 pH 122
    4.2.8 Thiobarbituric Acid (TBA) 125
4.3 Microbial Analysis 128
4.4 Sensory evaluation 129
5 CONCLUSION AND RECOMMENDATIONS FOR FURTHER RESEARCH

5.1 Conclusion 134
5.2 Recommendations for Further Research 135

REFERENCES 137
APPENDICES 157
BIODATA OF STUDENT 179
### LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Microbial concerns of <em>sous vide</em> products</td>
<td>51</td>
</tr>
<tr>
<td>2.2</td>
<td>Cooling legislation for cooked products in some European countries</td>
<td>59</td>
</tr>
<tr>
<td>4.1</td>
<td>Calculated pasteurization times of 13D and 6D for par-cooked <em>sous vide</em> Khorak-e-Mahicheh at 70, 75, 80, 85, 90 and 95°C</td>
<td>91</td>
</tr>
<tr>
<td>4.2</td>
<td>Calculated pasteurization times of 13D and 6D for raw-cooked <em>sous vide</em> Khorak-e-Mahicheh at 70, 75, 80, 85, 90 and 95°C</td>
<td>91</td>
</tr>
<tr>
<td>4.3</td>
<td>Effect of cooking method and storage time on hardness (N/cm²) of <em>Khorak-e-Mahicheh</em></td>
<td>95</td>
</tr>
<tr>
<td>4.4</td>
<td>Effect of cooking method and storage time on adhesiveness (Ns) of <em>Khorak-e-Mahicheh</em></td>
<td>97</td>
</tr>
<tr>
<td>4.5</td>
<td>Effect of cooking method and storage time on springiness (cm) of <em>Khorak-e-Mahicheh</em></td>
<td>99</td>
</tr>
<tr>
<td>4.6</td>
<td>Effect of cooking method and storage time on cohesiveness (dimensionless) of <em>Khorak-e-Mahicheh</em></td>
<td>101</td>
</tr>
<tr>
<td>4.7</td>
<td>Effect of cooking method and storage time on gumminess (N) of <em>Khorak-e-Mahicheh</em></td>
<td>103</td>
</tr>
<tr>
<td>4.8</td>
<td>Effect of cooking method and storage time on chewiness (N) of <em>Khorak-e-Mahicheh</em></td>
<td>105</td>
</tr>
<tr>
<td>4.9</td>
<td>Effect of cooking method and storage time on water activity (aw) of <em>Khorak-e-Mahicheh</em></td>
<td>109</td>
</tr>
<tr>
<td>4.10</td>
<td>Effect of cooking method and storage time on ΔE of <em>Khorak-e-Mahicheh</em></td>
<td>115</td>
</tr>
<tr>
<td>4.11</td>
<td>Effect of cooking method and storage time on moisture content (MC) of <em>Khorak-e-Mahicheh</em></td>
<td>117</td>
</tr>
<tr>
<td>4.12</td>
<td>Analysis of variance of cooking weight loss means</td>
<td>118</td>
</tr>
<tr>
<td>4.13</td>
<td>Effect of cooking method and storage time on water holding capacity (WHC) of <em>Khorak-e-Mahicheh</em></td>
<td>121</td>
</tr>
<tr>
<td>4.14</td>
<td>Effect of cooking method and storage time on pH of <em>Khorak-e-Mahicheh</em></td>
<td>124</td>
</tr>
<tr>
<td>4.15</td>
<td>Effect of cooking method and storage time on thiobarbituric acid (TBA) of <em>Khorak-e-Mahicheh</em></td>
<td>127</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Typical steps in <em>sous vide</em> processing</td>
</tr>
<tr>
<td>2.2</td>
<td>Traditionally cooked Iranian muscle beef stew (<em>Khorak-e-Mahicheh</em>)</td>
</tr>
<tr>
<td>3.1</td>
<td>Process flow for the preparation and processing of <em>Khorak-e-Mahicheh</em></td>
</tr>
<tr>
<td>3.2</td>
<td>Process flow for the preparation and processing of raw-cooked <em>sous vide Khorak-e-Mahicheh</em></td>
</tr>
<tr>
<td>3.3</td>
<td>Process flow for the preparation and processing of par-cooked <em>sous vide Khorak-e-Mahicheh</em></td>
</tr>
<tr>
<td>3.4</td>
<td>TA-XT2 Texture Analyser (stable micro system, Godalming, England)</td>
</tr>
<tr>
<td>3.5</td>
<td>A typical texture profile analysis force-time obtained from the TA-XT2 Texture Analyser</td>
</tr>
<tr>
<td>4.1</td>
<td>Time temperature profile for raw-cooked <em>sous vide Khorak-e-Mahicheh</em> at 70, 75, 80, 85, 90 and 95°C</td>
</tr>
<tr>
<td>4.2</td>
<td>Time temperature profile for par-cooked <em>sous vide Khorak-e-Mahicheh</em> at 70, 75, 80, 85, 90 and 95°C</td>
</tr>
<tr>
<td>4.3</td>
<td>Lethality curves for 13D processed raw-cooked <em>sous vide Khorak-e-Mahicheh</em> at 70, 75, 80, 85, 90 and 95°C</td>
</tr>
<tr>
<td>4.4</td>
<td>Lethality curves for 6D processed raw-cooked <em>sous vide Khorak-e-Mahicheh</em> at 70, 75, 80, 85, 90 and 95°C</td>
</tr>
<tr>
<td>4.5</td>
<td>Lethality curves for 13D processed par-cooked <em>sous vide Khorak-e-Mahicheh</em> at 70, 75, 80, 85, 90 and 95°C</td>
</tr>
<tr>
<td>4.6</td>
<td>Lethality curves for 6D processed par-cooked <em>sous vide Khorak-e-Mahicheh</em> at 70, 75, 80, 85, 90 and 95°C</td>
</tr>
<tr>
<td>4.7</td>
<td>Effect of cooking method and storage time on <em>a</em> (redness) of <em>Khorak-e-Mahicheh</em></td>
</tr>
<tr>
<td>4.8</td>
<td>Effect of cooking method and storage time on <em>b</em> (yellowness) of <em>Khorak-e-Mahicheh</em></td>
</tr>
<tr>
<td>4.9</td>
<td>Effect of cooking method and storage time on <em>L</em> (lightness) of <em>Khorak-e-Mahicheh</em></td>
</tr>
<tr>
<td>4.10</td>
<td>Mean comparisons of cooking weight loss</td>
</tr>
<tr>
<td>Section</td>
<td>Title</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>4.11</td>
<td>Effect of cooking method and storage time on color of <em>Khorak-e-Mahicheh</em></td>
</tr>
<tr>
<td>4.12</td>
<td>Effect of cooking method and storage time on aroma of <em>Khorak-e-Mahicheh</em></td>
</tr>
<tr>
<td>4.13</td>
<td>Effect of cooking method and storage time on tenderness of <em>Khorak-e-Mahicheh</em></td>
</tr>
<tr>
<td>4.14</td>
<td>Effect of cooking method and storage time on juiciness of <em>Khorak-e-Mahicheh</em></td>
</tr>
<tr>
<td>4.15</td>
<td>Effect of cooking method and storage time on overall acceptance of <em>Khorak-e-Mahicheh</em></td>
</tr>
</tbody>
</table>
LIST OF ABBREVIATIONS

aw                   Water Activity
ACMSF          The Advisory Committee on the Microbiological Safety of Food
ANOVA         Analysis of Variance
APHA            American Health Association
BHT               Butylated Hydroxy Toluene
CC                 Cook Chill
cm                  Centimeter
CFU/g            Colony-Forming Unit per gram
D                    Decimal Reduction Time
EB                  Electron Beaml
g                     Gram
ICMSF           The International Commission on Microbiological Specifications for Foods
in                   inch
kg                   Kilogram
kPa                 Kilo Pascal (Pressure Unit)
log                  Logarithm
M                    Molar
MC                  Moisture Content
min                Minute
mg                  Milligram
ml                  Milliliter
mm                  Millimeter
mmHg              millimetre of Mercury
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm/s</td>
<td>millimetre per second</td>
</tr>
<tr>
<td>N</td>
<td>Normal (concentration unit)</td>
</tr>
<tr>
<td>NACMCF</td>
<td>The National Advisory Committee on Microbiological Criteria for Foods</td>
</tr>
<tr>
<td>NFPA</td>
<td>National Food Processors Association</td>
</tr>
<tr>
<td>nm</td>
<td>Nano meter</td>
</tr>
<tr>
<td>NSW</td>
<td>New South Wales</td>
</tr>
<tr>
<td>°C</td>
<td>Degree centigrade</td>
</tr>
<tr>
<td>Pa</td>
<td>Pascal (Pressure unit)</td>
</tr>
<tr>
<td>s</td>
<td>Second</td>
</tr>
<tr>
<td>SVCC</td>
<td>Sous Vide Cook Chill</td>
</tr>
<tr>
<td>TBA</td>
<td>Thiobarbituric acid</td>
</tr>
<tr>
<td>TBARS</td>
<td>Thiobarbituric acid Reactive Substance</td>
</tr>
<tr>
<td>TPA</td>
<td>Texture Profile Analysis</td>
</tr>
<tr>
<td>μm</td>
<td>Micrometer</td>
</tr>
<tr>
<td>μl</td>
<td>Microliter</td>
</tr>
<tr>
<td>USFDA</td>
<td>The United States Food and Drug Administration</td>
</tr>
<tr>
<td>USNACMCF</td>
<td>The United States National Advisory Committee on Microbiological Criteria for Foods</td>
</tr>
<tr>
<td>UV</td>
<td>Ultra Violet</td>
</tr>
<tr>
<td>WHC</td>
<td>Water Holding Capacity</td>
</tr>
<tr>
<td>WOF</td>
<td>Warmed Over Flavor</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

Changing lifestyles have incited much activity in the food manufacturing and food service industries in developing new technologies for processing and packaging food in order to assume many of the tasks of preparing and cooking food which had usually taken place in the home or restaurant. In the home, meal preparation was traditionally the duty of the housewife, but as career opportunities and expectations have increased for women, the time available for meal preparation has decreased. The concept of family meal has also been affected since family members eating at different times due to different working patterns and personal preferences. In many cases, there is much less confidence in preparing raw foods to make a meal as traditional cookery skills. The starting material has also changed from traditionally using mostly raw materials such as meat, fish, and vegetables to buying in portioned cuts of meat, fish and poultry and peeled, diced or sliced vegetables ready prepared for cooking. Introduction of convenience foods such as chilled ready meals can afford these demands.

Importance of minimizing the costs associated with labor, equipment and energy has prompted the introduction of new systems for providing food on a large scale. Furthermore, higher income, increasing public knowledge of nutrition and request for a wider range of dishes has encouraged paying a premium for foods which are considered to have higher quality and nutritious (Creed and Reeve, 1998).
The *sous vide* method of food processing and preservation is a one way in which these demands may possibly be satisfied. *Sous vide* is a professional cooking method which employs plastic oxygen barriers and precise temperature controls to reduce oxidation and extend the usable shelf life of the product by diminishing contact with aerobic bacteria. The result is a final product with superior texture, increased tenderness and moisture, color retention improvement, amplified flavors, nutritional loss reduction and enhanced shelf life. It is also packaged in such a way that the food product is convenient to use (Tiampo, 2006; Church and Parson, 2000; Vaudagna *et al.*, 2002).

The most recent changes in the demand for meat, the interest in new red meat products, particularly convenience ones, has dramatically increased (Resurreccion, 2003). Red meat is a plentiful source of many essential and important nutrients and minerals. These nutrients and minerals are crucial for health and well-being, as well as key to human development and growth. The beef muscle consists of 75% water, 20% protein, 3% fat and 2% soluble non-protein substances. Out of the latter 2%, metals and vitamins constitute 3%, non-protein nitrogen-containing substances 45%, carbohydrates 34% and inorganic compounds 18%.

Hence, the *sous vide* system appears as an interesting alternative to development of conventional meat-base recipes and produce *sous vide* beef products (García-Segovia *et al.*, 2007; Szerman *et al.*, 2007a).
Many Iranian dishes require long time and intense labor for their preparation and cooking. *Khorak-e-Mahicheh* is a well-known product requiring carefully controlled heating and preparation. A typical preparation method consists of frying muscle slices or whole muscle in chopped onion, adding garlic cloves, black or white pepper, salt and final long time heating. Some recipes contain butter, lime juice and tomato paste to improve taste, color and flavor. This dish is served with steam-cooked rice. *Khorak-e-Mahicheh* has limited storage stability in refrigerated conditions because of its ingredients. The long preparation time and limited storage stability restrict its use in institutional food service or even at home. The development of the product with improved shelf life and ease of preparation would enhance the acceptance for home and catering consumption.

As a possible processing alternative to satisfy this purpose and ensure safety, this study aimed to develop product of *sous-vide Khorak-e-Mahicheh* based on the conventional method of processing and incorporating the heat treatment requirements of $10^6$ and $10^{13}$ decimal reduction of *Clostridium botulinum* and *Streptococcus faecium* respectively as reference microorganisms. Therefore the objectives of the study were:

1. To develop the processing technique for *sous vide Khorak-e-Mahicheh*.
2. To determine the heat penetration parameters and pasteurization value of *sous vide Khorak-e-Mahicheh* at different temperatures.
3. To investigate the effect of storage time on texture and other quality attributes of *sous vide Khorak-e-Mahicheh* during chilled storage.
4. To identify the feasible distinctions between three methods of processing.
2.1 Chilled Foods

The most general definition of a chilled food would include any food that happens to be refrigerated. However, the term ‘chilled foods’ has become much more restrictive in its meaning. For example, some authors use the term ‘refrigerated processed foods with extended durability’ to refer to foods that are cooked and then packaged and stored for extended periods, the most notable example of this class of foods are sous vide products (Brackett, 1992).

The purpose of chilling is to reduce the rate of food deterioration by inhibiting the chemical and biochemical changes and the activities of the microorganisms. Chilling alone is not able to prevent all microbial growth as the range of temperatures over which microorganisms can grow, is extremely wide. The use of chill temperature will reduce the rate and extent of microbial growth. Duun et al. (2008) defined that to minimize the growth of spoilage and pathogenic bacteria, the storage temperature must be reduced as much as possible, without affecting the product quality.
The length that the consumers store chilled foods after purchase will affect the safety of the purchases (Evans, 1998). Also, the methods of handling and storing chilled foods by the consumer at home can have significant effects on the quality and safety of food products.

Many documents have described the general and specific requirements for the hygienic manufacture of chilled foods (NFPA, 1989; AQIS, 1992). One of the best of them is Guidelines for Good Hygienic Practice in the Manufacture of Chilled Food (CFA, 1993) which has been set down in structured manner hygiene requirements for all main types of chilled foods. Thus, it classified chilled foods into four basic product categories: those manufactured from solely raw ingredients; those from a combination of raw and cooked ingredients; those from only cooked ingredients; and those manufactured by the ‘sous vide’ process. It further divides these groups into subgroups according to whether or not they are to be cooked when they are prepared for consumption. Specific requirements are described for each of the product categories, considering how the product is processed and further handling when prepared for consumption.

According to ACMSF (1992), chill-stored foods require a particularly high level of control during production and distribution in order to meet quality and safety requirements. As many microorganisms (including pathogenic bacteria and mycotoxigenic moulds) grow at chill storage temperatures, it is important to control the amount of these microorganisms in ingredients and products to the minimum as much as