UNIVERSITI PUTRA MALAYSIA

PROCESSING AND STORAGE CHARACTERISTICS OF *SOUS VIDE* IRANIAN BEEF STEW

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By

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

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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

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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. S*ous 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

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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 berasakan 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

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 dipantaukan menggunakan '*thermocouples*' yang dimasukkan ke dalam pek yang telah divakumkan. S*ous 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 lembapan, 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

‘*cohesiveness*’) secara significan ($p<0.05$). 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.

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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.

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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:

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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.

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NAGHMEH TAHERI HERAVI

Date: 16 June 2009

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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

mm/s	millimetre per second
N	Normal (concentration unit)
NACMCF	The National Advisory Committee on Microbiological Criteria for Foods
NFPA	National Food Processors Association
nm	Nano meter
NSW	New South Wales
ºC	Degree centigrade
Pa	Pascal (Pressure unit)
s	Second
SVCC	Sous Vide Cook Chill
TBA	Thiobarbituric acid
TBARS	Thiobarbituric acid Reactive Substance
TPA	Texture Profile Analysis
µm	Micrometer
µl	Microliter
USFDA	The United States Food and Drug Administration
USNACMCF	The United States National Advisory Committee on Microbiological Criteria for Foods
UV	Ultra Violet
WHC	Water Holding Capacity
WOF	Warmed Over Flavor

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 useable 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.

CHAPTER 2

LITERATURE REVIEW

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