



UNIVERSITI PUTRA MALAYSIA

**DEVELOPMENT OF PROCESSING TECHNIQUE FOR THE
PRODUCTION OF CHILLI (*CAPSICUM ANNUUM* VARIETY KULAI)
PUREE**

ERMINA SARI

FSTM 2007 8



**DEVELOPMENT OF PROCESSING
TECHNIQUE FOR THE PRODUCTION OF
CHILLI (*CAPSICUM ANNUUM* VARIETY
KULAI) PUREE**

ERMINA SARI

**MASTER OF SCIENCE
UNIVERSITI PUTRA MALAYSIA**

2007



**DEVELOPMENT OF PROCESSING TECHNIQUE
FOR THE PRODUCTION OF CHILLI
(*CAPSICUM ANNUUM* VARIETY KULAI) PUREE**

**By
ERMINA SARI**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirement for the Degree of Master of Science**

June 2007



Dedicated to

My mother, Gusmi Harwati and my late father, Sofyan Tana

**My beloved husband,
Totok Suswanto**

**My beloved son,
Nabiha Tegar Suswanto**

You are just beyond comparison.....

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science,

**DEVELOPMENT OF PROCESSING TECHNIQUE
FOR THE PRODUCTION OF CHILLI
(*CAPSICUM ANNUUM* VARIETY KULAI) PUREE**

By

ERMINA SARI

June 2007

Chairman : Associate Professor Nazamid Saari, PhD

Faculty : Food Science and Technology

Chilli puree is a product in semi-solid form having quality close to the fresh ones and is convenient to use. At present, the quality of chilli puree in the market is not acceptable to the food manufacturers as a raw material for making other products derived from chilli as it contains high amount of preservatives and has unattractive dark colour. Therefore, development of an appropriate processing technique for production of chilli puree having a quality acceptable to the users is of prime importance.

Response surface methodology (RSM) was used to determine the optimum conditions for drying chilli. Fresh chilli was dried using two different techniques; cabinet and vacuum oven dryer. Changes in the Hunter colour parameters (L , a , b) of chilli during drying were investigated. Sensory evaluation was used to determine the quality of dried chilli in terms of colour, texture, aroma and overall acceptability. It

was found that changes in colour during drying of chilli by cabinet oven drying were apparent. On the other hand, an increase in the temperature of vacuum oven dryer did not give significant effect on the colour of dried chilli produced. The optimum conditions for the cabinet oven drying of chilli were found to be at 50°C for 5 days, while that of vacuum oven drying was at 80°C for 7 hours.

Dried chillies (*Capsicum annuum* variety Kulai) were reconstituted using two different soaking techniques (cold water and boiled water soakings), crushing and stone-grinding into fine puree and pasteurized with and without citric and/or acetic acids. The quality attributes of chilli puree were evaluated in terms of pH, moisture, Hunter surface colour (*L*, *a*, *b* and hue angle and chroma), extractable colour (ASTA units) and capsaicinoid content. Results showed that different soaking techniques had a pronounced effect on the pH, moisture content, Hunter surface colour, extractable colour, hue angle and chroma and of the puree. However, chilli puree prepared by boiled-water soaking had lower capsaicin and di-hydro capsaicin concentrations compared to cold water soaking. Pasteurization at different pHs did not seem to give an effect on the Hunter surface colour (*L*, *a*, and *b*), ASTA unit and pungency of the purees produced. Overall, the combined treatments of boiled water soaking and pasteurized in the presence of acid(s) conferred purees of similar quality attributes.

The colour degradation kinetics of chilli puree prepared from dried chilli (*Capsicum annuum* variety Kulai) was evaluated using a fraction conversion technique during thermal treatment at 60, 70, 80 and 90°C (up to 30 min) and storage of chilli puree at 5, 28 and 45°C (up to 10 weeks). Chilli puree was subjected to heat treatment at different temperatures in a well-stirred water bath. Test samples were removed from

the water bath at selected time intervals (0-30 min after come-up), cooled immediately and analyzed for colour using Hunterlab colorimeter. Chilli puree colour was expressed in terms of tristimulus colour value a and combination ($L \times a \times b$). First order reaction kinetics adequately described the change in colour values during both thermal treatment and storage of puree. The quality of chilli puree stored at three different storage conditions during 10 weeks of storage were evaluated in terms of pH, water activity, Hunter colour (L , a , b and hue angle and chroma), extractable colour (ASTA units), capsaicinoid content, volatile compounds and microbiological quality. Different storage conditions used had significant effects on the hunter surface colour, extractable colour, hue angle and chroma, volatile compounds and microbiological quality of the final puree product. Capsaicinoids, pH and water activity values were retained during storage. Data obtained in this study showed that a combination of low temperature storage, pH and heat treatment synergistically enhanced the quality of chili puree and prolonged its shelf life.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Masters Sains,

**PEMBANGUNAN TEKNIK PEMROSESAN UNTUK PENGHASILAN
PURI CILI (*CAPSICUM ANNUUM* VARIETI KULAI)**

Oleh

ERMINA SARI

Jun 2007

Pengerusi : Profesor Madya Nazamid Saari, PhD

Fakulti : Sains dan Teknologi Makanan

Puri cili adalah produk berbentuk separuh pepejal yang mempunyai kualiti menyerupai cili segar dan sangat mudah untuk diguna. Pada masa ini, kualiti puri cili di pasaran tidak dapat diterima oleh pengusaha makanan sebagai bahan mentah untuk membuat produk lain berasaskan cili, kerana ianya mengandungi bahan pengawet yang tinggi dan memiliki warna gelap yang tidak menarik. Oleh yang demikian, pembangunan teknik yang sesuai untuk pembuatan puri cili yang mempunyai kualiti yang dapat diterima oleh pengguna adalah penting.

Response surface methodology (RSM) telah diguna bagi menentukan keadaan optimum pengeringan cili. Cili segar dikeringkan dengan mengguna dua kaedah yang berbeza, iaitu pengering ketuhar dan pengering vakum. Perbezaan warna (nilai L , a dan b) cili diselidiki semasa pengeringan. Pengamatan deria digunakan untuk menentukan kualiti cili kering dari segi warna, tekstur, bau dan penerimaan keseluruhan. Didapati bahawa perubahan warna semasa pengeringan cili menggunakan pengering ketuhar kelihatan

ketara. Sebaliknya, kenaikan suhu pengering vakum tidak memberikan perbezaan yang ketara terhadap warna cili kering yang dihasilkan. Keadaan yang optimum untuk mengeringkan cili menggunakan pengering ketuhar diperolehi pada suhu 50°C selama 5 hari, manakala pengeringan dengan pengering vakum diperolehi pada suhu 80°C selama 8 jam.

Cili (*Capsicum annum* variety Kulai) kering direndam menggunakan dua kaedah perendaman yang berbeza (perendaman air sejuk dan air mendidih), penghancuran dan penggilingan kepada puri yang halus dan pempasteuran dengan penambahan atau tanpa asid. Kualiti puri cili dianalisis dari segi pH, kelembapan, warna permukaan (L , a , b dan *hue angle* dan *chroma*), warna ekstrak (ASTA unit) dan kandungan capsaicinoid. Hasil penyelidikan menunjukkan perbezaan teknik perendaman memberikan pengaruh yang ketara berbeza terhadap pH, kelembapan, warna permukaan (L , a , b dan *hue angle* dan *chroma*), warna ekstrak (ASTA unit) puri yang dihasilkan. Walau bagaimanapun, puri cili yang diperbuat dengan perendaman dalam air mendidih menghasilkan kandungan capsaicin dan di-hydro capsaicin yang lebih rendah berbanding puri cili yang diperbuat dengan cara perendaman air sejuk. Pempasteuran pada pH yang berbeza tidak memberikan perbezaan yang ketara terhadap warna permukaan (nilai L , a , dan b), warna ekstrak dan tahap kepedasan puri yang dihasilkan. Keseluruhannya, gabungan perendaman dalam air mendidih dan pempasteuran dengan penambahan asid menghasilkan kualiti puri yang serupa.

Kinetik perubahan warna puri cili yang diperbuat dari cili kering (*Capsicum annum* variety Kulai) dianalisis menggunakan teknik konversi fraksi (*fraction conversion technique*) semasa perlakuan panas pada suhu 60, 70, 80 dan 90°C (selama 30 min)

dan penyimpanan puri cili pada suhu 5, 28 and 45°C (selama 10 minggu). Puri cili diberi perlakuan panas pada suhu yang berbeza di dalam kukusan air yang dikacau dengan baik. Sampel yang akan dianalisis dikeluarkan dari kukusan air pada selang masa yang tertentu (0-30 min setelah dikeluarkan), disejukkan sejeurus dikeluarkan dan dianalisis warna permukaannya menggunakan pengukur warna Hunter Lab. Warna permukaan puri cili ditunjukkan dari segi nilai a dan kombinasi $L \times a \times b$. Reaksi kinetic urutan pertama (*First-order reaction kinetics*) menunjukkan dengan jelas perubahan nilai warna semasa diberi perlakuan panas dan penyimpanan puri. Kualiti puri cili yang disimpan pada tiga keadaan penyimpanan yang berbeza selama 10 minggu dianalisis dari segi pH, aktiviti air, warna permukaan (L , a , b dan *hue angle* dan *chroma*), warna ekstrak (ASTA unit), kandungan capsaicinoid, kandungan bahan meruap dan kualiti mikrobiologi. Keadaan penyimpanan yang berbeza memberikan pengaruh yang berbeza secara ketara terhadap warna permukaan (L , a , b dan *hue angle* dan *chroma*), warna ekstrak (ASTA unit), kandungan bahan meruap dan kualiti mikrobiologi puri yang dihasilkan. Capsaicinoids, pH and aktiviti air tidak mengalami perubahan yang ketara semasa penyimpanan. Data yang diperolehi dari kajian ini menunjukkan, gabungan suhu penyimpanan yang rendah dan pH serta perlakuan panas dapat meningkatkan kualiti puri cili dan memanjangkan jangka masa hayat.

ACKNOWLEDGEMENTS

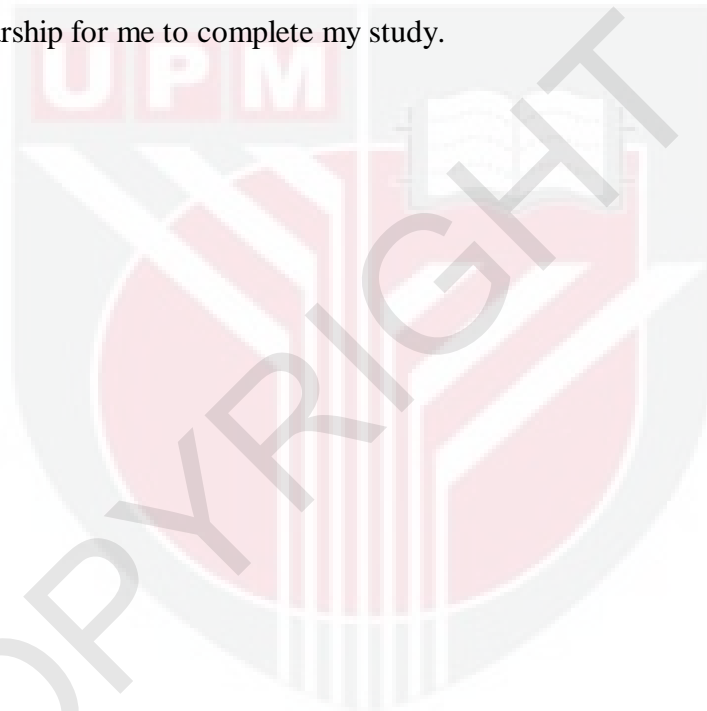
I would like to express my appreciation and sincere gratitude to my supervisor, Assoc. Prof. Dr. Nazamid Saari for his invaluable guidance, suggestions, constructive criticisms and constant encouragement throughout the course of study and in the preparation of this thesis. My deep appreciation and gratitude also goes to Dr. Nazimah Sheikh Abdul Hamid, Assoc. Prof. Dr. Azizah Osman and Mr. Dzulkifly Mat Hashim, members of my supervisory committee for their invaluable guidance and suggestions, constructive criticisms and encouragement.

I would like to thank the Department of Food Science and Technology, Universiti Putra Malaysia for providing the research facilities. I wish to thank to Mr Azman, Mrs. Jamaliah, Ms. Norlinawati for kind cooperation during experiment.

Last but not least, I am greatly indebted to my mother, Mrs. Gusmi Harwati, for her great loving support and my late father, Mr. Sofyan Tana who really wants me to finish my study. Appreciation also goes to my father in law, Mr. Kustomo and mother in law, Mrs. Suliyanti. I wish to express my deepest appreciation to my beloved husband, Mr. Totok Suswanto, my son, Nabiha Tegar Suswanto and my sister Mrs. Nora Sofiani, for their encouragement. Special thanks to my late aunty Mrs. Media Sandra and also Mrs. Puspita Deswina, who kindly offered help encouragement during my study.

I also would like to thank all my friends (Mr. Joko Susilo Utomo, Mrs. Greiche and husband, Raja Rohaya, Mohd. Reza, Mr. Willy, Mr. Asep, Noranizan, Azimah, Azura, Wan Zunairah and Afizah) who gave me encouragement and support during the period of my study at Universiti Putra Malaysia (UPM).

Finally, I am grateful to the Ministry of Science, Technology and Innovation Malaysia through the Intensification Research in Priority Areas (IRPA) for providing the scholarship for me to complete my study.



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 the Supervisory Committee were as follows:

Nazamid Saari, PhD

Associate Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Chairman)

Azizah Osman, PhD

Associate Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

Nazimah Sheikh Abdul Hamid, PhD

Lecturer
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

Dzulkifly Mat Hashim, M. Sc.

Lecturer
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

AINI IDERIS, PhD

Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 15 November 2007

TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	vi
ACKNOWLEDGEMENTS	ix
APPROVAL	xi
DECLARATION	xiii
LIST OF TABLES	xvii
LIST OF FIGURES	xx
LIST OF PLATES	xxii
CHAPTER	
1. INTRODUCTION	
1.1 Background	1.1
1.2 Objectives	1.4
2. LITERATURE REVIEW	
2.1 Chilli	2.1
2.1.1 Morphological Characteristics	2.4
2.1.2 Physical and Chemical Characteristics	2.7
2.1.3 Functional Components	2.10
2.2. Processed Products of Chilli	2.19
2.2.1 Dried Chilli	2.20
2.2.2 Chilli Powder	2.20
2.2.3 Chilli Puree	2.21
2.2.4 Chilli Bo	2.21
2.2.5 Chilli Sauce	2.23
2.3. Drying of Chilli	2.24
2.3.1 Types of Drying Techniques	2.24
2.3.2 Changes in Physical and Chemical Characteristics During Drying	2.26
2.4 Chilli Puree	2.30
2.4.1 Processing Method for Chilli Puree	2.30
2.4.2 Characteristics of Chilli Puree	2.31
2.4.3 Shelflife of Chilli Puree	2.34
2.4.4 Storage Conditions and Physico-chemical and Biochemical Changes During Storage	2.35
2.4.5 Kinetics of Colour Degradation	2.41
2.4.6 Acidulant	2.44

3.	OPTIMIZING CONDITIONS FOR DRYING CHILLI (<i>CAPSICUM ANNUUM</i> VARIETY KULAI) USING TWO DIFFERENT DRYING TECHNIQUES	
3.1	Introduction	3.1
3.2	Materials and Methods	3.5
	3.2.1. Materials	3.5
	3.2.2. Methodology	3.5
3.3	Results and Discussion	3.11
	3.3.1 Statistical Analysis	3.11
	3.3.2 Effect of Time and Temperature of Drying Chilli using Cabinet Vacuum Oven Drier	3.15
	3.3.3 Optimization Drying Chilli Using Cabinet and Vacuum Oven Drier	3.23
3.4	Conclusions	3.32
4.	EFFECT OF SOAKING TECHNIQUES AND PASTEURIZATION WITH AND WITHOUT ACIDS ON SOME QUALITY ATTRIBUTES OF CHILLI PUREE PREPARED FROM <i>Capsicum annuum</i> VARIETY KULAI	
4.1	Introduction	4.1
4.2	Materials and Methods	4.3
	4.2.1 Materials	4.3
	4.2.2 Methodology	
4.3	Results and Discussion	4.7
	4.3.1 Effect of Soaking Techniques on the Hunter Visual Colour, Extractable Colour, Hue Angle and Chroma, pH, Moisture and Capsaicinoids Content of the Puree	4.7
	4.3.2 Effect of Pasteurization at Different Acid(s) Concentration on the Colour and Capsaicinoids Content of Boiled-water Soaked Puree	4.11
4.4.	Conclusions	4.14
5.	COLOUR DEGRADATION KINETICS AND QUALITY CHARACTERISTICS OF CHILLI (<i>Capsicum annuum</i> VARIETY KULAI) PUREE DURING STORAGE	
5.1	Introduction	5.1
5.2	Materials	5.3
	5.2.1 Raw materials	5.3
	5.2.2 Methodology	5.3
5.3	Results and Discussion	5.9
	5.3.1 Degradation Kinetics of Chilli Puree during Thermal Treatment	5.9
	5.3.2 Effect of Storage Temperatures and Durations on the Hunter Visual Colour, Hue Angle, Chroma and Extractable Colour of Chilli Puree	5.14

5.3.3 Effect of Storage Temperatures and Durations on the pH, Water Activity and Capsaicinoids Content of Chilli Puree	5.18
5.3.4 Effect of Storage Temperatures and Durations on the Volatile Compounds of Chilli Puree	5.23
5.3.5 Microbiological Quality of Chilli Puree during Storage at Three Different Temperatures	5.27
5.4 Conclusions	5.34

6. CONCLUSIONS

Conclusions	6.1
-------------	-----

REFERENCES

R.1

APPENDICES

A.1

BIODATA OF THE AUTHOR

B.1

LIST OF TABLES

Table	Page
2.1 Estimated area, production and yield of chilli peppers in selected countries	2.3
2.2 Representative varieties of chilli in selected countries	2.4
2.3 Physical and chemical Alterations That Occur During the Ripening of Fleshy Fruits	2.8
2.4 Chemical composition of <i>Capsicum annuum</i> L.	2.10
2.5 Nutritional composition of red chili	2.11
2.6 Capsaicinoid content in selected sweet paprika samples	2.12
2.7 Capsaicinoid contents of eight individual fresh fruits (one purchase from Spain)	2.13
2.8 Total pigments and β -carotene in different coloured varieties of <i>Capsicum</i> fruits.	2.14
2.9 Pigment composition of different varieties of <i>Capsicum annuum</i> L (approximate percentage of total carotenoids)	2.15
2.10 Reflected and extracted colour of <i>Capsicum</i> powder made from fruit that were harvested at different colour stages and ripened.	2.16
2.11 Requirements for red chilli sauce	2.24
2.12 Effect of drying temperature on carotenoids degradation in cayenne powder on storage	2.27
2.13 Effect of drying on individual carotenoids of cayenne stored as whole pods	2.27
2.14 Browning compounds and colour values of paprika powder heated at 125°C for different times	2.29
2.15 Austchilli product specification	2.32
2.16 Physico-chemical and microbiological data on red chilli puree	2.33

2.17	Physico-chemical and microbiological data on red chilli puree	2.34
2.18	Microbiological data on coriander leaf puree during 6 months of storage	2.40
2.19	Microbiological data on chilli paste processed at 80°C for 15 min during 6 months storage at 37°C	2.40
2.20	Effect of storage conditions on colour retention in a chilli variety	2.41
2.21	Physical properties of citric acid	2.49
3.1	Combinations of drying time and temperature of cabinet and vacuum oven drier for drying of chilli.	3.7
3.2	Sensory attributes, moisture content and surface color of chilli after drying at cabinet oven drier	3.8
3.3	Sensory attributes, moisture content and surface color of chilli after drying at vacuum oven drier	3.9
3.4	Regression Coefficient, R^2 and p or probability for each of dependent variables of cabinet oven drying method	3.12
3.5	Regression Coefficient, R^2 and p or probability for each of dependent variables of vacuum drying method	3.13
3.6	Dependent variables for cabinet and vacuum oven dryer at optimum condition	3.31
4.1	The Hunter Surface, extractable colour, pH, moisture and pungency of chilli puree produced by two soaking techniques	4.9
4.2	The Hunter Surface colour, extractable colour, pH, moisture and pungency of chilli puree in the presence or absence of acid(s)	4.13
5.1	Kinetic parameters for colour changes during thermal processing (60, 70, 80 and 90°C) and storage (5, 28 and 45°C for 0-10 weeks)	5.13
5.2	Hunter L , a , b values, Hue angle, chroma and Asta unit of chilli puree during 10 weeks of storage at three different temperatures	5.18

- 5.3 Volatile compounds in chilli puree during 10 weeks of storage at three different temperatures 5.26
- 5.4 Microbiological counts on chilli puree during 10 weeks of storage at three different temperatures 5.32



LIST OF FIGURES

Figure		Page
2.1	Morphology of <i>Capsicum</i> spp.	2.6
2.2	Structure formula of citric acid	2.47
2.3	Structure formula of acetic acid	2.52
3.1	Response surface showing the effect of drying time and temperature of cabinet oven drying on (a) colour, (b) aroma, (c) texture, and (d) overall acceptability	3.17
3.2	Response surface showing the effect of drying time and temperature of cabinet oven drying on (a) moisture content, (b) <i>L</i> value, (c) <i>a</i> value, and (d) <i>b</i> value.	3.18
3.3	Response surface showing the effect of drying time and temperature of vacuum oven dryer on (a) colour, (b) aroma, (c) texture, and (d) overall acceptability	3.21
3.4	Response surface showing the effect of drying time and temperature of vacuum oven drying on (a) moisture content, (b) <i>L</i> value, (c) <i>a</i> value, and (d) <i>b</i> value.	3.22
3.5	Contour plot showing the effect of drying time and temperature of cabinet oven drying on (a) colour, (b) aroma, (c) texture, and (d) overall acceptability	3.25
3.6	Contour plot showing the effect of drying time and temperature of cabinet oven drying on (a) moisture content, (b) <i>L</i> value, (c) <i>a</i> value, and (d) <i>b</i> value.	3.26
3.7	Contour plot showing the effect of drying time and temperature of vacuum oven drying on (a) colour, (b) aroma, (c) texture, and (d) overall acceptability	3.28
3.8	Contour plot showing the effect of drying time and temperature of vacuum oven drying on (a) moisture content, (b) <i>L</i> value, (c) <i>a</i> value, and (d) <i>b</i> value	3.29
3.9	Response surface showing the optimization of drying time and temperature of cabinet oven drying.	3.30

3.10	Response surface showing the optimization of drying time and temperature of vacuum oven drying	3.31
5.1	First-order colour (Hunter <i>a</i> value) degradation kinetics of chilli puree at selected temperatures.	5.14
5.2	First-order colour (Hunter <i>L x a x b</i>) degradation kinetics of chilli puree at selected temperatures	5.15
5.3	Variation of colour degradation rate constants with temperature.	5.16
5.4	Effect of storage temperatures and durations on the pH of chilli puree	5.21
5.5	Effect of storage temperatures and durations on the water activity of chilli puree.	5.22
5.6	Effect of storage temperatures and durations on the capsaicin content of chilli puree.	5.23
5.7	Effect of storage temperatures and durations on the di-hydro capsaicin content of chilli puree	5.24

LIST OF PLATES

Plate		Page
A.4.1	Drying of chilli in cabinet oven drier	A.13
A.4.2	Dried chilli after drying in cabinet oven drier at 50°C for 5 days	A.13
A.4.3	Resulted chilli puree	A.14



CHAPTER 1

INTRODUCTION

1.1 Background

The *Capsicum* family belongs to the *Solanaceae* and is related to eggplants, potatoes and tomatoes (Bosland *et al.*, 1996). They most probably originated in Bolivia and Peru (Purseglove *et al.*, 1981; Bosland *et al.*, 1996) and were distributed after the discovery of America to other parts of the world. They now grow in all parts of the world (Somos, 1984) and are part of many cuisines. *Capsicum* fruit are berries, even though they are considered vegetables by consumers, and are either consumed as sweet or hot types.

The main uses of *Capsicums* vary according to their pungency and colour. Uses range from salads, using capsicum to add flavour, to cooked dishes, using fresh green and red chillies to add pungency, to using dried powdered spice of paprika and chilli to add red colour and pungency (Biacs *et al.*, 1989), to pickles, using for example Jalapeno chillies, and to sauces, using for example Tabasco and Habanero chillies. Fruit colour can be green, yellow or red; for dried spice production red fruit are used, which have ripened from their green unripe form.

Fresh *Capsicum* production grew worldwide from 11 in 1990 to 16 million tones (MT) in 1997 (FAO, 1999). Of that 9.5 MT are produced in Asia (FAO, 1999), with