



UNIVERSITI PUTRA MALAYSIA

**EFFECTS OF *STROBZLANTHES CRISPUS* CRUDE AND TEA
EXTRACTS IN
STREPTOZOTOCIN-INDUCED HYPERGLYCEMIC RATS**

MOHD FADZELLY ABU BAKAR

FPSK(M) 2006 28

**EFFECTS OF *STROBILANTHES CRISPUS* CRUDE AND TEA EXTRACTS IN
STREPTOZOTOCIN-INDUCED HYPERGLYCEMIC RATS**

MOHD FADZELLY ABU BAKAR

**MASTER OF SCIENCE
UNIVERSITI PUTRA MALAYSIA**

2005



**EFFECTS OF *STROBILANTHES CRISPUS* CRUDE AND TEA EXTRACTS IN
STREPTOZOTOCIN-INDUCED HYPERGLYCEMIC RATS**

By

MOHD FADZELLY ABU BAKAR

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

September 2005



*To my beloved mom and dad, for their outstanding
support and patience
To my lovely siblings; Adik, Ina and Ain
To diabetics and their families, clinicians and researchers
Who are at war fighting this disease*

fadzelly



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

EFFECTS OF *STROBILANTHES CRISPUS* CRUDE AND TEA EXTRACTS IN STERPTOZOTOCIN-INDUCED HYPERGLYCEMIC RATS.

By

MOHD FADZELLY ABU BAKAR

September 2005

Chairman: Associate Profesor Asmah Rahmat, PhD

Faculty: Medicine and Health Sciences

Strobilanthes crispus leaf has been used ethnomedically to treat diabetes mellitus and related disorders in Asia. The first part of this study is to develop a tea from leaves of *S. crispus* and investigate its antioxidant properties *in vitro*. Fermented and unfermented teas from young and old leaves of *S. crispus* were developed according to *Camellia sinensis* and *Camellia theifera* preparations for black and green tea, respectively. Three methods were used to determine the antioxidant activities i.e 1) β -carotene bleaching method 2) DPPH free radical scavenging assay 3) Ferric reducing/antioxidant power (FRAP) assay. The total phenolic content was also estimated using Folin-Ciocalteu method. The result showed that unfermented *S. crispus* tea displayed a higher antioxidant activity compared to fermented *S. crispus* tea. Tea developed from old or matured leaves possessed higher antioxidant activity compared to young leaves. However, commercial green (Sencha, UK) and black (Boh, Malaysia) tea that were developed from leaves of *C. sinensis* exhibited higher antioxidant activity among all



teas tested. The second part of this study was aimed at determining the effect of *S. crispus* crude extract on STZ-induced hyperglycemic rats. *S. crispus* (young and old leaves) were extracted with distilled water and given to normal and hyperglycemic rats at concentrations of 2.5, 5.0 and 7.5% for 21 days. Plasma glucose, lipid profile (total cholesterol, triglyceride, HDL-cholesterol, LDL-cholesterol), total antioxidant status and serum potassium and magnesium contents were determined on baseline (day 0), day 7 and day 21. The results showed that *S. crispus* crude extract at concentrations of 2.5, 5.0 and 7.5% from old or matured leaves reduced glucose level significantly in hyperglycemic rats ($p < 0.05$). Third part of this study evaluated the effect of *S. crispus* fermented and unfermented tea in STZ-induced hyperglycemic rats at a concentration of 2% for 21 days. Plasma glucose, lipid profile (total cholesterol, triglyceride, HDL-cholesterol, LDL-cholesterol), total antioxidant status and serum potassium and magnesium contents were determined during baseline (day 0), day 7 and day 21. The results showed that both fermented and unfermented *S. crispus* tea reduced glucose level in hyperglycemic rats ($p < 0.05$). Fermented and unfermented *S. crispus* tea also improved antioxidant status and lipid profile in hyperglycemic rats by lowering the total cholesterol, triglyceride, and LDL-cholesterol. Total antioxidant status and HDL-cholesterol also increased in hyperglycemic rats treated with fermented or unfermented tea *S. crispus*. Both fermented or unfermented *S. crispus* tea failed to prevent the reduction of serum magnesium in hyperglycemic rats.



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

**KESAN EKSTRAK KASAR DAN EKSTRAK TEH DARI DAUN
STROBILANTHES CRISPUS PADA TIKUS YANG DIARUH HIPERGLISEMIA
MENGUNAKAN STREPTOZOTOCIN**

Oleh

MOHD FADZELLY ABU BAKAR .

September 2005

Pengerusi: Profesor Madya Asmah Rahmat, PhD.

Fakulti: Perubatan dan Sains Kesihatan

Strobilanthes crispus telah digunakan terutamanya di Asia dalam perubatan tradisional untuk merawat diabetes mellitus dan penyakit yang berkaitan. Bahagian pertama kajian ini adalah untuk membuat teh dari daun *S. crispus* dan mengkaji ciri-ciri antioksidan dalam teh tersebut. Teh yang difermentasi dan yang tidak difermentasi dibentuk menggunakan kaedah membuah teh masing-masing dari daun *C. sinensis* dan *C. theifera*. Tiga kaedah digunakan untuk menentukan aktiviti antioksidan iaitu 1) Kaedah pelunturan β -karoten 2) Kaedah penghapusan radikal bebas DPPH 3) Kaedah penurunan ferik/kuasa antioksidan (FRAP). Kandungan fenolik keseluruhan juga ditentukan menggunakan kaedah Folin-Ciocalteu. Keputusannya menunjukkan bahawa teh *S. crispus* yang tidak difermentasi menunjukkan paras aktiviti antioksidan yang lebih tinggi dari yang difermentasi. Teh yang dibentuk dari daun tua menunjukkan aktiviti antioksidan yang lebih tinggi berbanding dengan daun muda. Walaubagaimanapun, teh hijau (Sencha, UK) dan teh hitam (Boh, Malaysia) yang

dibuat dari daun teh (*C. sinensis*) menunjukkan tahap aktiviti antioksidan yang paling tinggi dalam semua teh yang dikaji. Bahagian kedua kajian ini adalah untuk menentukan kesan ekstrak kasar pada tikus yang diaruh hiperglisemia menggunakan STZ. Ekstrak kasar daun *S. crispus* (daun muda dan tua) disediakan dengan menggunakan air suling dan diberi pada tikus normal and tikus hiperglisemia pada kepekatan 2.5%, 5.0% dan 7.5% selama 21 hari. Paras glukosa, profil lipid (kolesterol keseluruhan, trigliserida, HDL-kolesterol, LDL-kolesterol) plasma, status antioksidan keseluruhan dan kalium serta magnesium ditentukan pada hari 0, 7 dan 21. Keputusannya menunjukkan ekstrak kasar daun tua *S. crispus* pada kepekatan 2.5%, 5.0% dan 7.5% menurunkan paras glukosa secara signifikan pada tikus yang diaruh hiperglisemia ($p < 0.05$). Bahagian ketiga kajian ini adalah untuk menilai kesan pengambilan teh *S. crispus* (difermentasi atau tidak difermentasi) pada tikus normal and tikus hiperglisemia pada kepekatan 2.0% selama 21 hari. Paras glukosa, profil lipid (kolesterol keseluruhan, trigliserida, HDL-kolesterol, LDL-kolesterol) plasma, status antioksidan keseluruhan dan kalium serta magnesium ditentukan pada hari 0, 7 dan 21. Keputusannya menunjukkan bahawa ke dua-dua teh *S. crispus* yang difermentasi atau tidak difermentasi menurunkan secara berkesan paras glukosa plasma pada tikus yang diaruh hiperglisemia ($p < 0.05$). Kedua-dua teh *S. crispus* yang difermentasi atau yang tidak difermentasi juga mampu membaiki paras antioksidan keseluruhan dan juga membaiki profil lipid dalam tikus yang diaruh hiperglisemia dengan menurunkan paras kolesterol keseluruhan, trigliserida dan LDL-kolesterol. Status antioksidan keseluruhan dan HDL-kolesterol juga meningkat pada tikus hiperglisemia yang dirawat dengan teh *S. crispus* yang difermentasi atau yang tidak difermentasi. Walaubagaimanapun, ke dua-



dua teh tersebut gagal menghalang penurunan magnesium serum dalam tikus hiperglisemia.



ACKNOWLEDGEMENT

“In the name of Allah, The Most Gracious, The Most Merciful”

I thank Allah for His blessings and guidance in my life as a human, a Muslim, a son, a brother and what I have achieved so far. I wish to express my sincere appreciation and gratitude to Assoc. Prof. Dr. Asmah Rahmat, chairperson of my supervisory committee. Her keen interest, effort, advice and concern on my research project are much valued. I would also like to thank the other members of my supervisory committee: Assoc. Prof. Dr. Fauziah Othman for her insightful advice and interest, and Dr. Sharida Fakurazi. Their enthusiastic support, invaluable advice and constructive criticism are valuable. Special thanks to the entire technical staff of the Department of Nutrition and Health Sciences and Department of Clinical Laboratory Sciences, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Serdang, for their help and technical assistance. My deep gratitude and many thanks to all my friends and postgraduate students at UPM, for their encouragement, technical assistance and advice as well as friendly cooperation during my study. The most important, my special love and gratitude to my beloved family: My father, Abu Bakar Hj Isa; My mother, Salmah Hj Din; my siblings, Nurul Azreen, Nurul Raihana and Nurul Ain, for their love and continuous support, which has made this possible.



I certify that an Examination Committee met on 30 September 2005 to conduct the final examination of Mohd Fadzelly Abu Bakar on his Master of Science thesis entitled "The Effects of *Strobilanthes crispus* crude and tea extracts in streptozotocin-induced hyperglycemic rats" 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. Members of the Examination committee are as follows:

Mary Huang Soo Lee, PhD

Associate Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Chairman)

Norhaizan Mohd Esa, PhD


Lecturer
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Internal Examiner)

Muhajir Hamid, PhD

Lecturer
Faculty of Biotechnology and Biomolecular Sciences
Universiti Putra Malaysia
(Internal Examiner)

Musalmah Mazlan, PhD

Professor
Faculty of Medicine
Universiti Kebangsaan Malaysia
(External Examiner)


HASANAH MOHD GHAZALI, PhD
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

16 FEB 2006

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

Asmah Rahmat, PhD

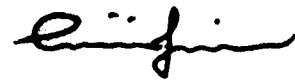
Associate Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Chairman)

Fauziah Othman, PhD

Associate Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Member)

Sharida Fakurazi, PhD

Lecturer
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Member)



AINI IDERIS, PhD
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 09 MAR 2006



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 or concurrently submitted for any other degree at UPM or other institutions



MOHD FADZELLY ABU BAKAR

Date: 15/2/2006

TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	v
ACKNOWLEDGEMENTS	viii
APPROVAL	ix
DECLARATION	xi
TABLE OF CONTENT	xii
LIST OF TABLES	xv
LIST OF FIGURES	xviii
LIST OF ABBREVIATIONS	xix
CHAPTER	
I INTRODUCTION	
1.1 Background	1
1.2 Problem Statement	4
1.3 Objectives	
1.31 General Objective	6
1.32 Specific Objectives	6
II LITERATURE REVIEW	
2.1 Introduction	7
2.2 Overview of Diabetes	9
2.2.1 Type 1 Diabetes Mellitus	10
2.2.1.1 Definition	10
2.2.1.2 Etiology	11
2.2.1.3 Current Treatment of type 1 diabetes	13
2.2.2 Type 2 Diabetes Mellitus	14
2.2.2.1 Definition	14
2.2.2.2 Etiology	15
2.2.2.3 Current Treatment of type 2 diabetes	16
2.3 Complication of diabetes and related disorder	16
2.4 Minerals and diabetes	19
2.41 Magnesium	19
2.42 Potassium	21
2.5 Streptozotocin	21
2.6 The Integrated Antioxidant System	22
2.7 Total antioxidant status (FRAP assay)	25
2.8 Lipid peroxidation process	26



2.9	Phenolic Phytochemical as Antioxidant	28
2.10	Free Radical, Antioxidant and Diabetes	29
2.11	Diabetes and Medicinal Plants/Herbs	30
2.12	Tea	31
2.13	<i>Pecah beling (Strobilanthes crispus)</i>	33
III	METHODOLOGY	
3.1	Plant Material	37
3.2	Preparation of <i>S. crispus</i> tea	38
	3.2.1 Fermented	38
	3.2.2 Unfermented	40
3.3	Determination of Antioxidant Activity	41
	3.3.1 Extraction	41
	3.3.2 β -carotene Bleaching Method	41
	3.3.3 DPPH Free Radical Scavenging Activity	43
	3.3.4 Ferric reducing / Antioxidant power (FRAP assay)	43
	3.3.5 Determination of Total Phenolic Content	45
3.4	<i>In vivo</i> study	46
	3.4.1 Types of leaves	46
	3.4.2 Preparation of <i>S. Crispus</i> Crude Extract	46
	3.4.3 Nutritional composition of basal diet	46
	3.4.4 Preparation of <i>S. Crispus</i> tea Extract	47
	3.4.5 Study protocol	
	3.4.5.1 Experimental Rats	48
	3.4.5.2 Induction of Hyperglycemic Rats	48
	3.4.5.3 Study Design	49
	3.4.6 Biochemical Analysis	
	3.4.6.1 Lipid profile analysis	52
	3.4.6.1.1 Total cholesterol	52
	3.4.6.1.2 Triglyceride	54
	3.4.6.1.3 HDL-cholesterol	54
	3.4.6.1.4 LDL-cholesterol	56
	3.4.6.2 Glucose	56
	3.4.6.3 FRAP assay	57
	3.4.6.4 Serum Mineral Content (Potassium and Magnesium)	57
3.5	Statistical Analysis	58
IV	RESULTS & DISCUSSIONS	
4.1	Total phenolic content and antioxidant properties of <i>S. crispus</i> tea	59
	4.1.1 Total Phenolic Content	61
	4.1.2 DPPH Free Radical Scavenging Activity	64
	4.1.3 β -carotene Bleaching Method	67
	4.1.4 Ferric reducing / Antioxidant power (FRAP assay)	69



4.2	Effects of <i>Strobilanthes crispus</i> crude extracts on	
4.2.1	Body and Liver weight	74
4.2.2	Glucose	78
4.2.3	Total cholesterol	84
4.2.4	Triglyceride	88
4.2.5	LDL-cholesterol	91
4.2.6	HDL-cholesterol	93
4.2.7	Total Antioxidant Status	95
4.2.8	Potassium	99
4.2.9	Magnesium	102
4.3	Effects of <i>Strobilanthes crispus</i> tea extracts on	
4.3.1	Body and Liver weight	105
4.3.2	Glucose	107
4.3.3	Total cholesterol	111
4.3.4	Triglyceride	114
4.3.5	HDL-cholesterol	117
4.3.6	LDL-cholesterol	119
4.3.7	Total Antioxidant Status	121
4.3.8	Potassium	124
4.3.9	Magnesium	125
VI	CONCLUSION AND RECOMMENDATION	
5.1	Conclusions	128
5.2	Recommendations	129
	BIBLIOGRAPHY	130
	AWARDS AND PUBLICATIONS	156
	BIODATA OF THE AUTHOR	158



LIST OF TABLES

Table		Page
2.1	Reactive oxygen species (ROS)	23
2.2	Conditions associated with oxidative damage	24
2.3	Components of antioxidant protection	25
2.4	Free radical scavenging enzymes	25
2.5	The comparison of the nutritional composition of <i>S. crispus</i> leaves, fermented <i>S. crispus</i> tea (young and old leaves), unfermented <i>S. crispus</i> tea (young and old leaves) as well as green and black teas	36
3.1	Percentage of main nutrient in basal diet	47
3.2	Treatment groups for the effect of <i>S. crispus</i> crude extracts	50
3.3	Condition of AAS in determination of minerals	61
4.1	Total phenolic content of the hot water extract of <i>S. crispus</i> teas.	63
4.2	DPPH free radical scavenging activity of hot water extract of <i>S. crispus</i> teas, commercial green and black tea as well as synthetic antioxidant (BHT)	66
4.3	Antioxidant activity using β -carotene bleaching method of hot water extract of <i>S. crispus</i> teas, commercial green and black tea as well as synthetic antioxidant (BHT)	69
4.4	Antioxidant activity using FRAP (Ferric Reducing/Antioxidant Power) of hot water extract of <i>S. crispus</i> tea, commercial green and black tea.	71
4.5	Abbreviations for each treatment group (<i>S. crispus</i> crude extracts)	73



4.6	Effects of <i>S. crispus</i> crude extract on body weight (g) in normal and hyperglycemic rats	75
4.7	Effects of <i>S. crispus</i> crude extract on liver weight (g) in normal and hyperglycemic rats	77
4.8	Effects of <i>S. crispus</i> crude extract on glucose level (mmol/l) in normal and hyperglycemic rats	80
4.9	Effects of <i>S. crispus</i> crude extract on total cholesterol (mmol/l) in normal and hyperglycemic rats	86
4.10	Effects of <i>S. crispus</i> crude extract on triglyceride (mmol/l) in normal and hyperglycemic rats	89
4.11	Effects of <i>S. crispus</i> crude extract on LDL-cholesterol (mmol/l) in normal and hyperglycemic rats	92
4.12	Effects of <i>S. crispus</i> crude extract on HDL-cholesterol (mmol/l) in normal and hyperglycemic rats	94
4.13	Effects of <i>S. crispus</i> crude extract on total antioxidant status (FRAP value) ($\mu\text{mol/l}$) in normal and hyperglycemic rats	97
4.14	Effects of <i>S. crispus</i> crude extract on serum potassium (K) level ($\mu\text{g/ml}$) in normal and hyperglycemic rats	101
4.15	Effects of <i>S. crispus</i> crude extract on serum magnesium (Mg) level ($\mu\text{g/ml}$) in normal and hyperglycemic rats	104
4.16	Effect of <i>S. crispus</i> tea on body weight (g) in normal and STZ-induced hyperglycemic rats	106
4.17	Effect of <i>S. crispus</i> tea on liver weight (g) in normal and STZ-induced hyperglycemic rats	107
4.18	Effect of <i>S. crispus</i> tea on plasma glucose level (mmol/l) in normal and STZ-induced hyperglycemic rats	108
4.19	Effect of <i>S. crispus</i> tea on total cholesterol level (mmol/l) in normal and STZ-induced hyperglycemic rats	112
4.20	Effect of <i>S. crispus</i> tea on triglyceride level (mmol/l) in normal and STZ-induced hyperglycemic rats	115



4.21	Effect of <i>S. crispus</i> tea on HDL-cholesterol level (mmol/l) in normal and STZ-induced hyperglycemic rats	118
4.22	Effect of <i>S. crispus</i> tea on LDL-cholesterol level (mmol/l) in normal and STZ-induced hyperglycemic rats	120
4.23	Effect of <i>S. crispus</i> tea on total antioxidant status ($\mu\text{mol/l}$) in normal and STZ-induced hyperglycemic rats	122
4.24	Effect of <i>S. crispus</i> tea on serum level potassium (K) ($\mu\text{mol/L}$) in normal and STZ-induced hyperglycemic rats	125
4.25	Effect of <i>S. crispus</i> tea on serum magnesium level (Mg) ($\mu\text{mol/L}$) in normal and STZ-induced hyperglycemic rats	126



LIST OF FIGURES

Figure		Page
1.1	<i>Strobilanthes crispus</i> ZII 109 (L) Bremek or <i>Saricocalix crispus</i> ZII 109 (L) Bremek (Acanthaceae)	3
2.1	Pathogenesis of type 1 diabetes mellitus	11
2.2	Molecular structure of streptozotocin	22
3.1	<i>S. crispus</i> young leaves (the apex to the 5 th leaf)	37
3.2	<i>S. crispus</i> old leaves (8 th leaf to the 12 leaf).	38
3.3	Fermented <i>S. crispus</i> tea (young leaves)	39
3.4	Fermented <i>S. crispus</i> tea (old leaves)	40
3.5	Unfermented <i>S. crispus</i> tea (young leaves)	40
3.6	Unfermented <i>S. crispus</i> tea (old leaves)	41



LIST OF ABBREVIATIONS

AAS = atomic absorption spectrometer

FRAP = ferric reducing ability of plasma or ferric reducing / antioxidant power

HDL-cholesterol = high density lipoprotein cholesterol

LDL-cholesterol = low density lipoprotein cholesterol

VLDL-cholesterol = very low density lipoprotein cholesterol

Min = minute

Hr = hour

Temp = temperature

TBA = thiobarbituric acid

TCA = trichloroacetic acid

DPPH = 1,1-diphenyl-2-picrylhydrazyl

HSDA = N-(2-hydroxy-3-sulfopropyl)-3, 5- dimethoxyaniline

STZ = streptozotocin

GOD = glucose oxidase

POD = peroxidase

TPTZ = 2,4,6-tripyridyl-s-triazine



CHAPTER I

INTRODUCTION

1.1 Background

Prevalence of diabetes in adults worldwide was estimated to be 4.0% in 1995 and this figure was estimated to rise to 5.4% by the year 2025. The prevalence is higher in developed than in developing countries. The number of adults with diabetes in the world will rise from 135 million in 1995 to 300 million in the year 2025. The major part of this numerical increase will occur in developing countries including Malaysia. There will be a 42% increase, from 51 to 72 million, in the developed countries and a 170% increase, from 84 to 228 million, in developing countries. Thus, by the year 2025, more than 75% of people with diabetes will reside in developing countries, as compared with 62% in 1995 (King *et al.*, 1998).

Diabetes is a costly disease and is associated with major long-term implications, not only for the health and well being of the affected individuals, but also for the government. WHO (2002) reported that the direct health costs of treating diabetic patients range from 2.5% to 15% of annual budget, depending on local diabetes prevalence and effectiveness of the treatment available. WHO estimated that there are over 171 million people worldwide who are afflicted with diabetes mellitus (WHO, 2004). These complications contribute to the enormous cost, both economic and



personal, that are associated with this disease. Generally, symptoms of diabetes complications develop years after this disease has occurred (Foster, 1991).

In Malaysia, the high demand for herbs has caused some herbs to be imported from other countries in high quantities. Based on estimated by the Director of Pusat Sumber Genetik Tumbuhan, Institut Biosains, UPM, Dr. Mohd Saad found that value of imported medicinal plants in Malaysia has increased from RM 167 million (1990) to RM 401 million (1997). Meanwhile, the value of medicinal plants exports have also increased from RM 17 million in 1990 to 58 million in 1997. In *Berita Minggu Newspaper* (1998), he also said that research from their institute found that 80% of the world's population still depend on traditional medicine, including herb. World Health Organization (WHO), as reported in the *Berita Minggu Newspaper* estimated that approximately 75 to 95% of world population still depend on traditional medicine for health care.

Malaysia is a country blessed with many kinds of herbs or plants which is frequently used in traditional medicine. In Malaysia, over 15 000 species of higher plants were found and about 1200 of these plant species have been reported to have potential pharmaceutical value some of which are being used as herbal medicine (Soepadmo, 1991). Furthermore, throughout the development of human culture, the use of natural products (especially from medicinal plants) has had magical-religious significance and different points of view regarding the concepts of health and disease existed within each culture (Rates, 2001)



One of the herbs that have great potential and is believed to have health-giving properties is “*pecah beling*” or *Strobilanthes crispus* (Figure 1.1). It is commonly known as “*daun pecah beling*” in Jakarta or “*enyoh kilo*”, “*kecibeling*” or “*kejibeling*” in Java (Sunarto, 1977). It is also locally known as “*pecah kaca*” or “*jin batu*”.



Figure 1.1 : *Strobilanthes crispus* ZII 109 (L) Bremek or *Saricocalix crispus* ZII 109 (L) Bremek (Acanthaceae)

Traditionally, the leaves of pecah beling are boiled with water and the filtrates used in traditional medicine in Malaysia and Indonesia as antidiabetic, diuretic, antilytic and laxative agents. This plant has many cystoliths of calcium carbonate and an infusion is mildly alkaline (Perry & Metzger, 1980). A recent study indicated that the water extract of *S. crispus* contained compounds that inhibits the proliferation of retrovirus; an agent in viral disease such as acquired immune deficiency syndrome (AIDS) and adult T-cell Leukemia (Kusumoto *et al.*, 1992). This plant also possesses antimicrobial properties (Soediro *et al.*, 1983), high antioxidant activity (Ismail *et al.*, 2000), anticancer properties (Endrini, 2003) and antihepatocarcinogenesis (Jaksa *et al.*, 2004)

1.2 Problem statement

Until today, there is no treatment that can completely cure diabetes mellitus. Presently, insulin is used to treat diabetes mellitus type 1. On the other hand, the pharmacological agents currently used for the treatment of type 2 diabetes include sulphonylureas, biguanide, thiazolidinedione and acarbose. These agents however have restricted usage due to several undesirable side effects and failure to significantly alter the course of diabetic complications. Current insulin regimens (in type 1 diabetes mellitus) are problematic in maintaining physiological blood glucose profile (Groop *et al.*, 1985). Hypoglycemic agent such as glibenclamide can cause acidosis and impair cardiac function (Legtenberg *et al.*, 2002) and is not effective in long-term treatment (Gerich *et al.*, 1985). In addition, hypoglycemic drug such as sulphonylurea, leads to a higher risk

