UNIVERSITI PUTRA MALAYSIA

EFFECTS OF ANTIOXIDANT AND DIETARY FIBER CONTENT OF FRESH AND OVEN-DRIED RED PITAYA FRUIT *(Hylocereus polyrhizus.)* ON HYPERCHOLESTEROLEMIC AND INSULIN-RESISTANT RATS

ALIREZA OMIDIZADEH

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By

ALIREZA OMIDIZADEH

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DEDICATION

To Sania, Helia and Dina

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

EFFECTS OF ANTIOXIDANT AND DIETARY FIBER CONTENT OF FRESH AND OVEN-DRIED RED PITAYA FRUIT *(Hylocereus polyrhizus.)* ON HYPERCHOLESTEROLEMIC AND INSULIN-RESISTANT RATS

By

ALI REZA OMIDI ZADEH

February 2009

Chairman: Associate Professor Dr. Rokiah Mohd Yusof

Faculty: Medicine and Health Sciences

This study was designed to investigate the effect of antioxidant content and soluble dietary fiber of red pitaya fruit *(Hylocereus polyrhizus)* on hypercholesterolemic and insulin resistant rats. In the laboratory, red pitaya fruit (*Hylocereus polyrhizus)* was subjected to five different thermal processes: oven drying at 95°C for 30min, oven drying at 95°C for 60min, oven drying at 105°C for 60min, drum drying, and spray drying. Total phenolic contents, radical scavenging activity, antioxidant activity and dietary fiber contents of the fresh and processed red pitaya were subsequently determined. The results of the study revealed that the length of the temperature time was more damaging to total phenolic contents, radical scavenging, and antioxidant activity of this fruit compared to high heating temperatures. The effect of long time (30-60 minutes) oven heating temperatures (95-105°C) on antioxidant parameters of red pitaya were highly significant compared to fresh one ($p < 0.05$). Among all of the heating temperatures, drum drying was the best method for preservation of total

phenolic contents, radical scavenging and antioxidant activity with 7%, 8%, and 13% reduction, respectively; and 95°C for 30 minutes oven drying was the best process for dietary fiber parameters with 8%, 0%, and 2% decreases in soluble, insoluble, and total dietary fibers, respectively. From the laboratory studies, two thermal processed pitaya with distinct proportions of phenolic contents, radical scavenging activity, and soluble dietary fibers were determined. The first thermal processed pitaya was the heated one at 95°C for 30 minutes and contained low phenolic contents and radical scavenging activity with almost intact soluble dietary fiber. The second one was heated pitaya at 105°C for 60 minutes with low in all of the studied biologically active components. These two thermal processed pitayas along with fresh pitaya were tested, as supplements, on high cholesterol (hypercholesterolemic) and high fructose-fed (insulin resistant) rats during 6 weeks treatment in the curative studies. The results showed that fresh red pitaya decreased total cholesterol, LDL-Cholesterol, glucose level, and also increased the serum total antioxidant power in hypercholesterolemic rats, significantly ($p < 0.05$). Moreover, the atherosclerotic changes induced by cholesterol supplement in rats were reversed by fresh pitaya. The hypocholesterolemic and anti-atherogenic effects of both oven-heated pitaya at 95°C for 30 min, and oven-heated pitaya at 105°C for 60 min contained low phenolic contents and radical scavenging activity were not significant. Fresh red pitaya could significantly reduce insulin level, insulin/glucose ratio, triglyceride, total cholesterol, and glucose level ($p < 0.05$) in insulin resistant rats. Besides, it improved glucose intolerance and increased the serum total antioxidant capacity, significantly ($p < 0.05$). The intima-media thickness of the abdominal aorta was significantly lower in fresh pitaya-fed rats than the positive control ($p < 0.05$), and

there were no noticeable changes in their endothelial layer. The anti-atherogenic and anti-dyslipidemic effects of heated pitaya 95°C for 30 min contained low content of phenolic contents and radical scavenging activity was not significant, but it decreased insulin level, insulin/glucose ratio, glucose level and glucose intolerance, significantly ($p < 0.05$). The heated pitaya 105°C for 60 min contained low content of phenolic contents, radical scavenging activity, and soluble dietary fiber had no effective role in improving the insulin resistance, dyslipidemia and atherogenesis. The data clearly showed that fresh red pitaya (that its antioxidants and dietary fibers remained intact) was capable of attenuating the hypercholesterolemia, insulin resistance and atherosclerotic changes induced by cholesterol and fructose supplement in rats. The hypocholesterolemic and anti-atherogenic effects of heated pitaya 95°C for 30 min contained low content of phenolic contents and radical scavenging activity, but almost intact soluble dietary fiber were not significant, but it improved insulin resistance (hyperinsulinemia). The heated pitaya 105°C for 60 min contained low content of phenolic contents, radical scavenging activity, and soluble dietary fiber had no effective role in improving the hypercholesterolemia, insulin resistance and atherogenesis. To conclude, antioxidant content of red pitaya fruit is very important for ameliorating dyslipidemia in hypercholesterolemic and insulin resistant rats; and red pitaya without enough antioxidant and soluble dietary fiber content is not able to play an effective role in the management of hypercholesterolemia and insulin resistance. These results will be useful for nutritionists and food scientists to use this tropical fruit as a nutritious product in the food industry to safeguard health and manage the hypercholesterolemia, insulin resistance and metabolic syndrome.

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

KESAN KANDUNGAN ANTIOKSIDAN DAN FIBER DIET BUAH PITAYA MERAH (*Hylocereus polyrhizus*) SEGAR DAN KERING KETUHAR KE ATAS TIKUS HIPERKOLESTEROLEMIK DAN RESISTAN INSULIN

Oleh

ALI REZA OMIDI ZADEH

Februari 2008

Pengerusi: Profesor Madya Dr Rokiah Mohd Yusof

Fakulti: Perubatan dan Sains Kesihatan

Kajian ini dibentuk untuk mengkaji kesan kandungan antioksidan dan fiber larut diet buah pitaya merah (*Hylocereus polyrhizus*) ke atas tikus hiperkolesterolemik dan resistan insulin. Daripada kajian makmal, dua produk telah dihasilkan yang mempunyai proporsi sebatian fenolik, kesan penghapusan radikal, dan fiber larut diet yang berbeza. Produk pertama ialah pitaya yang dipanaskan pada suhu 95^{o}C selama 30 minit mengandungi rendah sebatian fenolik dan aktiviti penghapusan radikal, dan hampir semua fiber larut masih kekal. Produk kedua adalah pitaya yang dipanaskan pada suhu 105^{o}C selama 60 minit yang mana mengandungi rendah semua komponen bahan aktif biologi. Dua produk ini bersama dengan buah pitaya segar telah diuji sebagai suplemen ke atas tikus tinggi kolesterol (hiperkolesterolemik) dan tinggi diet fruktosa (resistan insulin) selama 6 minggu dalam kajian pemulihan. Data dengan jelas menunjukkan bahawa buah pitaya segar (kesemua antioksidan dan fiber larut diet masih kekal) berupaya menggurangkan hiperkolesterolemia, resistan insulin dan perubahan arterosklerotik yang diaruhkan oleh kolesterol dan suplemen fruktosa pada tikus. Kesan hiperkolesterolemik dan anti-arterogenik buah pitaya yang dipanaskan (95^{o}C-30min) mengandungi rendah sebatian fenolik dan aktiviti penghapusan radikal, tetapi hampir semua fiber larut diet masih kekal) tidak signifikan, tetapi ia memperbaiki resistan

insulin (hiperinsulinemia). Pitaya yang dipanaskan pada 105^{o}C-60min (mengandungi rendah sebatian fenolik, aktiviti penghapusan radikal, dan fiber larut diet) tidak berkesan dalam memperbaiki hiperkolesterolemia, resistan insulin dan arterogenesis. Kesimpulannya, kandungan antioksidan buah pitaya merah adalah penting dalam memperbaiki dislipidemia dalam tikus hiperkolesterolemik dan resistan insulin; dan pitaya merah tanpa kandungan antioksidan dan fiber larut tidak berupaya memain peranan berkesan dalam pengurusan hiperkolesterolemia dan resistan insulin. Keputusan kajian ini amat berguna kepada pakar pemakanan dan saintis makanan dalam mengguna buah-buahan tropikal sebagai produk berkhasiat dalam industri makanan bagi melindungi kesihatan dan mengurus hiperkolesterolemia, resistan insulin dan sindrom metabolik.

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I certify that a Thesis Examination Committee has met on **20 February 2009** to conduct the final examination of **Ali Reza Omidi Zadeh** on his thesis entitled "**Effects of Antioxidant and Dietary Fiber Content of Fresh and Oven-Dried Red Pitaya Fruit *(Hylocereus polyrhizus.)* on Hypercholesterolemic and Insulin-Resistant rats"** in accordance with Universities and University colleges Act 1971 and the Constitution of Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Mohd Nasir Mohd Taib, PhD
Associate Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Chairman)

Fauziah Othman, PhD
Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Internal Examiner)

Asmah Rahmat, PhD
Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Internal Examiner)

Ayub Mohd Yatim, PhD
Associate Professor
Faculty of Science and Technology
Universiti Kebangsaan Malaysia
(External Examiner)

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

Date: 28 April 2009

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

Rokiah Mohd Yusof, PhD
Associate Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Chairman)

Amin Ismail, PhD
Associate Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Member)

Mohd Zuki Abu Bakar, PhD
Associate Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Member)

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

Date: 14 May 2009

DECLARATION

I declare that the thesis is 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 concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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ALIREZA OMIDIZADEH

Date: 18 March 2009

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CHD	Coronary heart disease
CVD	Cardiovascular diseases
CI	confidence interval
DASH	Dietary Approach to Stop Hypertension
DPPH	2,2-Diphenyl-1-picryl-hydrazyl
FRAP	Ferric reducing ability of plasma
GAE	Gallic acid equivalent
GDM	gestational diabetes mellitus
HDL	High density lipoprotein
HDL-PH	HDL phospholipids
IDF	Insoluble dietary fiber
IFG	Impaired Fasting Glycemia
IGT	Impaired Glucose Tolerance
LDL	Low density lipoprotein
MDA	Malondialdehyde
RR	relative risk
SDF	Soluble dietary fiber
TAA	Total antioxidant activity
TC	Total cholesterol
TDF	Total dietary fiber
TG	Triglyceride
TGRLP-C	Triglyceride rich lipoprotein

TPC	Total phenolic compounds
TPH	Total phospholipids
WHO	World health organization

CHAPTER 1

INTRODUCTION

It is completely certain that the nutritional sciences and food industry play a prominent role in the prevention and treatment of common chronic diseases. They always endeavour to present healthy diet and nutritious products to promote good health and prevent illnesses, especially two important killer and disabling disorders, cardiovascular diseases (CVD) and diabetes. Healthy diet consists of daily eating at least 5 servings of fruits and vegetables, limiting the salt intake (WHO, 2007), and less sugar and saturated fat consumption (WHO, 2006). Research studies show that diets rich in fruits and vegetables protect us against important risk factors of CVD (WHO, 2007; Ignarro *et al*., 2007), coronary heart disease (CHD), stroke (Bazzano *et al*., 2002; Joshipura *et al*., 2001; Liu *et al*., 2001; Sasazuki, 2001; Zhao and Chen, 2001; Liu *et al*., 2000a; Menotti *et al*., 1999), and type2 diabetes (WHO, 2006). They are capable to improve the lipid profile (Gorinstein *et al*., 2004; Leontowicz *et al*., 2001; Aprikian *et al*., 2001), insulin resistance (Xi *et al*., 2007; Dimo *et al*., 2002), and glucose levels (Virdi *et al*., 2003). Also, to maintain the quality and value of food, including the maintenance of micronutrients and fortification of processed foods with the desired nutrients are the attempts of food industry to reduce the burden of CVD and diabetes.

Cardiovascular disease (CVD) is the number one cause of death. An estimated 17.5 million people died from CVD in 2005, representing 30 % of all global deaths. CVD is not only problem of the developed countries: around 80% of all CVD deaths worldwide take place in developing countries (WHO, 2007). According to the facts of 2002, the main cause of death at all ages in Malaysia was ischemic heart disease, with 13,000 cases. Moreover, we can add 5,000 deaths for hypertensive heart