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

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

By

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DEDICATION

To Sania, Helia and Dina
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EFFECTS OF ANTIOXIDANT AND DIETARY FIBER CONTENT OF FRESH AND OVEN-DRIED RED PITAYA FRUIT (*Hylocereus polyrhizus*) ON HYPERCHOLESTEROLEMIC AND INSULIN-RESISTANT RATS

By

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February 2009

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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
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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 hiperkolesterollemik 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 oC 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 oC 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 (hiperkolesterollemik) 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 diaruukan oleh kolesterol dan suplemen fruktosa pada tikus. Kesan hiperkolesterollemik dan anti-arterogenik buah pitaya yang dipanaskan (95 oC-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°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 menggunakan 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 would like to express my deepest and heartiest thanks and indebtedness to my supervisor, Chairman of the Supervisory Committee, Associate Professor Dr. Rokiah Mohd Yusof for her guidance throughout my study in the midst of her heavy responsibilities. I greatly appreciate her strong encouragement which has driven my enthusiasm for further scientific studies.

I am very grateful to Associate Professor Dr. Amin Ismail for his valuable advice and words of encouragement. Appreciation also goes to Associate Professor Dr. Mohd Zuki Abu Bakar for his help in completing this research.
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.

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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.

ALIREZA OMBIDZADEH

Date: 18 March 2009
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LIST OF ABBREVIATIONS

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
MDF  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
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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 type 2 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 a 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