UNIVERSITI PUTRA MALAYSIA

NUTRITIONAL, PHYSICO-CHEMICAL AND HEALTH-PROMOTING PROPERTIES OF SELECTED WATERMELON (Citrullus lanatus (Thunb.) Matsum. & Nakai) VARIETIES

SABEETHA BINTI SARMIN

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By

SABEETHA BINTI SARMIN

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SABEETHA BINTI SARMIN

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Chair: Professor Amin Ismail, PhD

Faculty: Medicine and Health Science

Watermelon (*Citrullus lanatus*) is a popular fruit among Malaysian. Red-fleshed seedless, red-fleshed seeded and yellow-fleshed watermelon are mostly selected as a dessert and available throughout the year in local markets. However, studies that look into the health properties of watermelon are still lacking. Therefore, this study determined the nutritional, the physico-chemical and the health-promoting properties of different types of watermelons. The results obtained that red-fleshed seedless watermelon contained 89.6 ± 4.3% moisture, while red-fleshed seeded and yellow-fleshed watermelon had 87.5 ± 2.6 % and 87 ± 2.7 %, respectively. Furthermore, no significant difference was detected for most nutritional and physico-chemical analyses between the samples. However, there were significant differences for colour value (L*, a* and b*) and amount of sucrose. Yellow-fleshed watermelon has the highest values for L* (49.99 ± 6.92), followed by red-fleshed seedless watermelon (43.44 ± 3.48) and red-fleshed seeded watermelon (38.2 ± 5.09). Yellow-fleshed watermelon also has the lowest value of a* (5.77 ± 2.00) and the highest value of b* (32.59 ± 8.77). Types of sugars present in red-fleshed seedless, red-fleshed seeded and yellow-fleshed watermelon were glucose, fructose and sucrose. The amount of total sugar was 95 ± 25.2 mg/g for red-fleshed seedless, 113.8 ± 31.6 mg/g for red-fleshed seeded and 103.1 ± 27.7 mg/g for yellow-fleshed watermelon. There was a positive and strong correlation between total soluble solid and total sugar (r^2 = 0.75). Meanwhile, the antioxidant contents among these watermelons were evaluated using total phenolic content (TPC), *2,2-diphenyl-1-picrylhydrazyl* radical scavenging (DPPH), Trolox equivalent antioxidant capacity (TEAC) and ß-carotene bleaching. The red-fleshed seedless watermelon had the highest amount of phenolic content (21.58 ± 2.9 mg GAE/100g edible portion) and ß-carotene bleaching activity (57.29 ± 3.53%) while red-fleshed seeded watermelon had the highest amount of antioxidant capacity (1.17 ± 0.43 µmol TE/g edible

portion) and percentage radical scavenging activity of DPPH (21.14 ± 2.03) compared to yellow-fleshed watermelon. Furthermore, the highest correlation between the red-fleshed and yellow-fleshed watermelon showed a positive correlation (r^2 = 0.877) with a significant difference ($p<0.01$) observed between total phenolic content and ß-carotene bleaching activity, while the lowest correlation (r^2 = 0.344) had no significant difference for total phenolic content with antioxidant capacity. The glycemic index was conducted on 14 healthy subjects who that consumed 25 g of available carbohydrate portions of glucose (standard food) and four test foods (red-fleshed seedless watermelon, red-fleshed seeded watermelon and yellow-fleshed watermelon, as well as a glass of red-fleshed seedless watermelon juice) in random order after an overnight fast. Red-fleshed seedless watermelon was usually processed as juice than red-fleshed seeded and yellow-fleshed watermelon. Glucose was measured at 0, 15, 30, 45, 60, 90 and 120 min after intake of the test foods. Incremental areas under the curve were calculated, whereas the glycemic index was determined by expressing the area under the curve after the test foods, as a percentage of the mean area under the curve after consuming standard food, was carried out. The results showed that the area under the curve for a portion of red-fleshed seedless was 98.17 ± 6.39, red-fleshed seeded (94.10 ± 7.45), yellow-fleshed (92.95 ± 8.73), and a juice of red-fleshed seedless (98.89 ± 6.38) did not have any significant difference ($p<0.05$). It means the glycemic index among samples did not significant differ statistically. The glycemic index of a portion fruit and the juice of red-fleshed seedless watermelon was 51, while red-fleshed seeded watermelon was 48 and yellow-fleshed watermelon was 47. The study showed that different colours of watermelon contributed to different antioxidant capacities and the red-fleshed watermelon had the highest antioxidant content. Furthermore, all watermelons sample could be classified as low GI food (GI value below 51) with the strong influences of component of sugar contents due to linear negative relationship between blood glucose response and glycemic index value, as well as with the amount of fructose for red-fleshed seedless, red-fleshed seeded, and yellow-fleshed watermelon.

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

NILAI PEMAKANAN, CIRI FIZIK-KIMIA DAN CIRI-CIRI PENGGALAK KESIHATAN BAGI VARIETI BUAH TEMBIKAI (*Citrullus lanatus* (Thunb.) Matsum. & Nakai)

Oleh

SABEETHA BINTI SARMIN

Oktober 2015

Pengerusi: Professor Amin Ismail, PhD

Fakulti: Perubatan dan Sains Kesihatan

Tembikai (*Citrullus lanatus*) merupakan antara buahan yang popular dalam kalangan rakyat Malaysia. Tembikai merah tanpa biji, tembikai merah berbiji dan tembikai kuning sering dipilih sebagai pencuci mulut dan mudah didapati sepanjang tahun. Walau bagaimanapun, kajian bercirikan kesihatan buah tembikai masih rendah. Oleh yang demikian, kajian ini dijalankan bagi memberi tumpuan untuk menentukan nilai pemakanan, fizik-kimia dan ciri penggalak kesihatan buah tembikai merah dan kuning. Hasil kajian mendapati tembikai merah tanpa biji mengandungi 89.6 ± 4.3 % peratus kelembapan, manakala tembikai merah berbiji dan tembikai kuning mempunyai 87.5 ± 2.6 % dan 87 ± 2.7 %, peratus kelembapan masing-masing. Tiada perbezaan yang signifikan untuk kebanyakan analisis pemakanan dan fizik-kimia antara jenis tembikai. Walau bagaimanapun, terdapat perbezaan yang signifikan bagi penentuan warna (L*, a* dan b*) dan kandungan sukrosa. Tembikai kuning mempunyai nilai kecerahan warna L* paling tinggi (49.99 ± 6.92), diikuti oleh nilai L* tembikai merah tanpa biji (43.44 ± 3.48) dan nilai L* tembikai merah berbiji (38.2 ± 5.09). Tembikai kuning mempunyai nilai a* yang terendah (5.77 ± 2.00) dan nilai b* yang paling tinggi (32.59 ± 8.77). Kandungan gula dalam tembikai merah berbiji, tembikai merah tanpa biji dan tembikai kuning terdiri daripada glukosa, fruktosa dan sukrosa. Jumlah keseluruhan gula adalah 95 ± 25.2 mg / g untuk tembikai merah tanpa biji, 113.8 ± 31.6 mg / g untuk tembikai merah berbiji dan 103.1 ± 27.7 mg / g untuk tembikai kuning. Terdapat korelasi yang positif dan kuat antara jumlah pepejal larut dengan jumlah gula (r^2 = 0.75). Kandungan antioksidan telah dinilai menggunakan kaedah analisis kandungan jumlah fenol (TPC), "*2,2-diphenyl-1-picrylhydrazyl radikal"* (DPPH), "*Trolox Equivalent Antioxidant Capacity"* (TEAC) dan "*ß-carotene bleaching"*. Tembikai merah tanpa biji mempunyai jumlah tertinggi kandungan fenolik (21.58 ± 2.9 mg GAE / 100g bahagian boleh dimakan) dan aktiviti "*ß-carotene bleaching*" (57.29 ± 3.53%) manakala tembikai merah berbiji mempunyai jumlah tertinggi

kapasiti antioksidan (1.17 ± 0.43 μmol TE / g bahagian boleh dimakan) dan peratus aktiviti radikal memerangkap daripada DPPH (21.14 ± 2.03) berbanding tembikai kuning. Hubungan antara tembikai merah dan tembikai kuning menunjukkan korelasi positif tertinggi (r^2 = 0.877) dan perbezaan yang ketara ($p < 0.01$) diperhatikan antara jumlah kandungan fenolik dan "*ß-carotene bleaching assay*", manakala korelasi yang paling rendah (r^2 = 0.344) dengan perbezaan yang signifikan diperhatikan antara jumlah kandungan fenolik dengan kapasiti antioksidan. Penentuan indeks glisemik telah dijalankan ke atas 14 subjek sihat. Sebanyak 25 g karbohidrat tersedia terdiri daripada glukosa (makanan rujukan) dan empat makanan ujian (tembikai merah tanpa biji, tembikai merah berbiji dan tembikai kuning, serta segelas jus tembikai merah tanpa biji) diberikan secara rawak kepada subjek selepas berpuasa semalaman. Jus tembikai merah tanpa biji dipilih kerana ia sering diproses sebagai jus berbanding tembikai merah berbiji dan tembikai kuning. Nilai glukosa plasma darah diukur pada 0, 15, 30, 45, 60, 90 dan 120 min selepas pengambilan makanan rujukan dan ujian. Kawasan bawah lengkung telah dikira dan indeks glisemik ditentukan sebagai peratusan berdasarkan pengiraan kawasan bawah lengkung makanan ujian daripada min kawasan bawah lengkung makanan rujukan. Hasil kajian menunjukkan bahawa nilai kawasan di bawah lengkung untuk tembikai merah tanpa biji adalah 98.17 ± 6.39, tembikai merah berbiji adalah 94.10 ± 7.45, tembikai kuning 92.95 ± 8.73 dan jus tembikai merah tanpa biji, 98.89 ± 6.38 tidak mempunyai perbezaan yang signifikan ($p < 0.05$). Secara statistik, indeks glisemik antara sampel tidak mempunyai perbezaan signifikan. Indeks glisemik bagi tembikai merah tanpa biji dan jus tembikai merah tanpa biji adalah 51 manakala tembikai merah berbiji adalah 48 dan tembikai kuning adalah 47. Kajian menunjukkan buah tembikai mempunyai kapasiti antioksidan yang berbeza berdasarkan warna buahan tersebut dan tembikai merah mempunyai kandungan antioksidan tertinggi. Semua sampel tembikai diklasifikasikan sebagai makanan rendah nilai GI (bawah 51) yang dipengaruhi oleh komponen kandungan gula. Hal ini berikutan terdapat hubungan linear secara negatif antara aras glukosa darah dengan jumlah fruktosa bagi kesemua tembikai merah dan tembikai kuning.

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I certify that a Thesis Examination Committee has met on 23rd October 2015 to conduct the final examination of Sabeetha binti Sarmin on her thesis entitled "Nutritional, Physico-chemical and Health-Promoting Properties of Selected Watermelon (*Citrullus lanatus (Thunb.) Matsum. & Nakai*) Varieties" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the 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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Associate Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Chairman)

Azrina bt Azlan, PhD
Associate Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Internal Examiner)

Wan Rosli bin Wan Ishak, PhD
Associate Professor
Nutrition Program
School of Health Sciences
Universiti Sains Malaysia
Malaysia
(External Examiner)

ZULKARNAIN ZAINAL, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 17 November 2015

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:

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

Barakatun Nisak bt Mohd Yusof, PhD
Associate Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectrophotometer
AOAC	Association of Official Analytical Chemists
AUC	Area under calculation
ß	Beta
ºB	Brix
BCB	Beta-carotene bleaching assay
BHT	Butylated Hydroxytoluene
BMI	Body mass index
ºC	Celsius
cm	Centimetre
CHO	Carbohydrate
DOA	Department of Agriculture
DPPH	*2,2-Diphenyl-1-picrylhydrazyl*
FAMA	Federal Agricultural Marketing Authority
g	Gram
GAE	Gallic acid equivalent
GI	Glycemic Index
HPLC	High performance liquid chromatography
hr	Hour
iAUC	Incremental area under calculation
IDF	Insoluble dietary fibre
kcal	Kilocalorie
kg	Kilogram

l	litre
M	Molarity
mg	Miligram
min	Minute
ml	Millilitre
mm	Millimetre
MoA	Ministry of Agriculture and Agro-based Industry
µm	Micrometre
N	Normality
nm	Nanometre
RD	Red-fleshed seeded watermelon
RM	Ringgit Malaysia
RS	Red-fleshed seedless watermelon
SD	Standard deviation
SDF	Soluble dietary fibre
SEM	Standard error means
TDF	Total dietary fibre
TE	Trolox equivalent
TEAC	Trolox equivalent antioxidant capacity
TPC	Total phenolic content
UPM	Universiti Putra Malaysia
Y	Yellow-fleshed watermelon
%	Percent

CHAPTER 1

INTRODUCTION

Recommended high intake of fruits is always highlighted as following a healthy diet and lifestyle. Most people start to select and consume more and variety of fruits in their daily diet. As we all know, fruits provide a lot of benefits to the body system. Besides rich in nutritional value, fruits also have antioxidant compounds that help in fighting certain diseases and delaying the ageing process (Feskanich et al., 2000). Variety of fruits can be found easily in Malaysia. Watermelons, oranges and mangoes are usually chosen as dessert and side dish.

Watermelon (*Citrulus lanatus*) is easily found at any event such as wedding ceremony, festive ceremony and others ceremony in Malaysia. Due to the Malaysian climate as a tropical country, watermelon is not a seasonal fruit and available throughout the year to gain reputation as a popular fruit. Besides being served as a portion of fresh fruit dessert, watermelon can also be consumed as fruit juice. Watermelon is also known as a thirst relieved food and refreshing drinks during the hot season and sunny day. According to Quek et al. (2007), watermelon juice has higher concentrated source of lycopene; one type of carotenoids.

The nutritional data are important parameters for determining the quality of a food. The proximate compositions include moisture content, protein, carbohydrate, dietary fibre and ash. All of these components will mix well as important balanced and healthy food. For example, the components of dietary fibres play a big role in digestion and absorption in the human body. Insoluble dietary fibre is the edible portion of plants or analogous carbohydrates that cannot be digested in the small intestine and can only occur in the large intestine in humans (AACC, 2000).

Physico-chemical properties are also important factors as a sign of maturity stage for watermelon. Size, weight, total soluble solid, pH, total acidity, sugar content and colour determination are used as maturity measurements. According to the Malaysian standard for watermelon (MS 1028:2005), the maturity of watermelon is divided into three stages of maturity index, three classes of grade and four types of sizes. The premium level of maturity will give a higher price to the fruit market.

In addition, the study of glycemic index and relationship between antioxidant, radical scavenging activities and phenolic content of fruit has been thought previously as a potential prevention of disease.

1.1 Problem statements

Today, there are high demands of watermelon as juice and fresh fruit. The red-fleshed seedless always being a popular choice as a juice than red-fleshed seeded and yellow-fleshed watermelon. There are also increasing demands of health-promoting attributes of watermelon. However, only few studies of the varieties of watermelon have been done and available. The most focused was about the nutritional, physico-chemical and antioxidant studies of the red-fleshed watermelon. No information is currently available on the comparison of quality preference of the red-fleshed and yellow-fleshed watermelon. Although there are a lot of studies done on watermelon, the glycemic index of yellow-fleshed watermelons and juice of red-seedless watermelon has not been determined.

Under Third National Agriculture policy outlined by Ministry of Agriculture and Agro-based Industry (MoA), production of watermelon was chosen as one of priority crops. In 2009, Malaysia occupied the 41st place in all watermelon-producing countries, with a production of 154,416 tones and a harvested area of approximately 9,241 hectares (DOA, 2009). By 2015, Malaysian DOA predicts around 12,516 hectares land use as watermelon farm and 294,425 metric tons of watermelons to be produced due to it being chosen as one of the priority crops under the Third National Agriculture policy and continue to achieve the production as agro-food commodities to grow around 4% a year as stated in The National Agro-food policy (2011-2020).

1.2 Significance of the study

This study will be used as initiative in promoting the benefits of eating watermelons as the regular daily diet. Other than that, this study is important to explore and evaluate the quality of watermelon fruit. This study is a preliminary study of the glycemix index that uses the yellow-fleshed watermelon and red-fleshed seedless juice as a test food. Red-fleshed seedless fruit is the popular juice than red-fleshed seeded and yellow-fleshed watermelon. This study will help the dieticians and nutritionists to educate their patients and general people in deciding their fruit portions based on the terms of glycemic index and other health properties. It will also be used as a future database reference of glycemic index of the watermelons.

Furthermore, by exploring this information about health-promoting properties of watermelon, the food technologist will be more interested to choose watermelon as materials of a high value product development. Moreover, this study will help to renew the nutritional composition in Federal Agricultural Marketing Authority (FAMA) booklet of the local watermelon. According to statistics report from MoA (2013), around RM 59.85 million export trades coming from watermelon commodities. Moreover, for watermelon to remain as the domestic production and high export commodity over Thailand, Indonesia and Philippines (Chubashini et al., 2011), the demands for better quality and nutritional aspects of the fruits are another challenge that needs to be handled.

1.3 Objectives of the study

1.3.1 General Objective

To investigate the nutritional, physico-chemical and health-promoting properties of the red-fleshed and yellow-fleshed watermelon.

1.3.2 Specific Objectives

1. To determine the nutritional composition and physico-chemical properties of selected watermelon (red-fleshed seedless watermelon, red-fleshed seeded watermelon and yellow-fleshed watermelon).

2. To determine an antioxidant as health-promoting properties of the selected watermelon (red-fleshed seedless watermelon, red-fleshed seeded watermelon and yellow-fleshed watermelon).

3. To determine the glycemic index as the health-promoting properties of the selected watermelon (red-fleshed seedless watermelon, red-fleshed seeded watermelon and yellow-fleshed watermelon) and red-fleshed seedless watermelon juice.

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