MINERALS, PHYTATE AND TANNIN CONTENTS IN SELECTED THAI FRUITS FOR HEALTH AND DISEASES GUILDLINES

CHANINNEAT TORSAHAKUL

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE (NUTRITION)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2007

Thesis

Entitled

MINERALS, PHYTATE AND TANNIN CONTENTS IN SELECTED THAI FRUITS FOR HEALTH AND DISEASES GUILDLINES

Chaninneat Torsahakul
Miss Chaninneat Torsahakul
Candidate

Assist. Prof. Ratchanee Kongkachuichai
Ph.D.(Food Science and Technology)
Major-Advisor

Rin Charoensiri
Miss Rin Charoensiri
M.Sc.(Nutrition and Dietetics)
Co-Advisor

Assoc. Prof. Pongtorn Sungpuag
D.Sc. (Nutrition)
Co-Advisor

Prof. M.R. Jisnuson Svasti, Ph.D
Dean
Faculty of Graduate Studies

Prof. Surat Komindr, M.D., F.R.C.P. (T)
Chair
Master of Science Program in Nutrition
Faculty of Medicine, Ramathibodi Hospital and Institute of Nutrition

Thesis
Entitled

MINERALS, PHYTATE AND TANNIN CONTENTS IN SELECTED THAI FRUITS FOR HEALTH AND DISEASES GUILDLINES

was submitted to the Faculty of graduate Studies, Mahidol University
for the degree of Master of Science (Nutrition)
on
May 29, 2007

Chaninneat Torsahakul
Miss Chaninneat Torsahakul
Candidate

Prasan Swatsitang
Assist. Prof. Prasan Swatsitang
Ph.D.(Nutritional Biochemistry)
Chair

Pongtorn Sungpuag
Assoc. Prof. Pongtorn Sungpuag
D.Sc. (Nutrition)
Member

Ratchanee Kongkachuichai,
Assist. Prof. Ratchanee Kongkachuichai,
Ph.D.(Food Science and Technology)
Member

Rin Charoensiri
Miss Rin Charoensiri
M.Sc. (Nutrition and Dietetics)
Member

Emorn Wasantwisut
Assoc. Prof. Emorn Wasantwisut,
Ph.D.(Nutrition Biochemistry and metabolism)
Director
Institute of Nutrition
Mahidol University

Prof. M.R. Jisnuson Svasti,
Ph.D.
Dean
Faculty of Graduate Studies
Mahidol University

Prof. Rajata Rajatanavin
M.D., F.A.C.E.
Dean
Faculty of Medicine,
Ramathibodi Hospital
Mahidol University

ACKNOWLEDGEMENT

The success of this thesis can been attributed to the extensive support and assistance from my major advisor, Assist. Prof. Ratchanee Kongkachuichai and my co-advisor, Assoc. Prof. Pongtorn Sungpuag and Miss Rin Charoensiri. I deeply thank them for their valuable advice, encouragement, guidance and constructive criticism, which this research.

I wish to thank Assoc. Prof. Prasan Swatsitang, for kindness in examining the research instrument and providing suggestions for improvement, and who was the chair and external examiner of the thesis defense.

I wish to thank Miss Aurawan Kringkasemsree, Ms. Benjawan Boonsong and all food chemistry staffs for their contribution in laboratory facilities and technical assistance.

I wish to thank Mahidol University and Mahidol University Alumni Association for support and encouragement the finance.

My sincere appreciation is expressed to all my friends for their friendship, contribution in laboratory facilities, and technical assistance.

Finally, I greatly appreciate and deepest gratitude to my family for their love, entirely care, sincerity, understanding, support and encouragement both finance and strength, during my study. The usefulness of this thesis, I dedicate to my father, my mother and all the teachers who have taught me since my childhood.

Chaninneat Torsahakul

MINERALS, PHYTATE AND TANNIN CONTENTS IN SELECTED THAI FRUITS FOR HEALTH AND DISEASES GUIDELINES

CHANINNEAT TORSAHAKUL 4737730 RANU/M

M.Sc. (NUTRITION)

THESIS ADVISORS: RATCHANEE KONGKACHUICHAI, Ph.D. (FOOD SCIENCE AND TECHNOLOGY), PONGTORN SUNGPUAG, D.Sc. (NUTRITION), RIN CHAROENSIRI, M.Sc. (NUTRITION AND DIETIETICS)

ABSTRACT

A total of 37 varieties of fresh fruits and 4 kinds of fruits in syrup were collected from 6 local markets and supermarkets in Bangkok during January to December 2006. The objectives were to determine macro and micro minerals (sodium; Na, potassium; K, magnesium; Mg, calcium; Ca, iron; Fe, zinc; Zn and copper; Cu), total polyphenol, tannin, catechin and phytate content and to determine molar ratios between phytate and micro-elements, and to calculate these nutrients and non-nutrients from one portion of each fruit group in food exchange lists. Sodium and potassium contents were determined using flame atomic absorption spectrophotometer and other minerals were determined using inductively coupled plasma–optical emission spectrometry (ICP-OES). All fruits were high in K (29.25 to 405.60 and 28.30 to 79.98 mg/100g edible portion for fresh fruits and fruits in syrup), especially ripe banana (Kai and Hawm varieties) and durian (Chanee variety) (309.75, 346.98 and 405.60 mg/100g edible portion). Both fruits and fruits in syrup were poor sources of some macro-minerals (Na, Mg and Ca) and micro-minerals (Fe, Cu, Zn) with ranged from 0.59 to 16.32 (Na), 3.08 to 25.21(Mg), 1.17 to 22.09(Ca), 0.08 to 0.33(Fe), 0.04 to 0.27(Cu) and 0.04 to 0.28(Zn) mg/100g edible portion. Total polyphenol, tannin and catechin were determined using Spectrophotometer. Total polyphenol, tannin and catechin content of all fruit samples ranged from 4.67 to 322.63 mgGAE, 0.62 to 43.37 mg tannic acid equivalent and 0.01 to 21.44 mg catechin equivalent/100g edible portion. Sugar apple (Nahng variety) had the highest amounts of total polyphenol, tannin and catechin contents with approximately 322.63, 43.37 and 21.44 mg/100g edible portion. Phytate content was determined using ion-pair reverse-phase chromatography. Phytate content ranged from 0.01 to 6.02 mg/100g edible portion. The highest phytate content was found in dragon fruit. (6.02 mg/100g edible portion). When considering the amount of macro–micro minerals in fruits and fruits in syrup from one portion of food exchange list, all samples in this study had a small amount of macro-micro minerals with ranging from 0 to 11 (Na), 1 to 21 (Ca), 2 to 27 (Mg), 0.1 to 0.6 (Fe) and 0 to 0.3 (Zn) mg/portion, respectively, except K and Cu, since almost all fruit samples were good source of potassium and copper, especially dragon fruit (325 mg/portion) which provided 9% of Thai RDI for K per one portion, lychee (Hohnghooway variety; 0.19 mg/portion) and green grape (0.26 mg/portion) which provide 10% and 13% of Thai RDI for Cu per one portion. Strawberry was the highest source of total polyphenol (397.13 mgGAE/portion) and tannin (28.49 mg tannin acid equivalent/portion) while star fruit is the greatest source of catechin (12.79 mg catechin equivalent/portion). The range of phytate in all samples was between 0.02 to 7.22 mg/portion. The highest of phytate content was found in dragon fruit. However, the molar ratios between phytate and micro-elements of the present study were less than 2.06 for Phy/Fe, 4.20 for Phy/Zn and 39 for Ca×Phy/Zn.

KEY WORDS: MINERAL/ PHYTATE/ POLYPHENOL/ TANNIN/ FRUITS

228 pp.

เกลือแร่ชนิดต่างๆ ไฟเตทและแทนนินในผลไม้ไทยเพื่อการแนะนำทางด้านโภชนาการ
(MINERALS, PHYTATE AND TANNIN CONTENTS IN SELECTED THAI FRUITS FOR HEALTH AND DISEASES GUIDELINES)

ชนิลเนตร ต่อสหะกุล 4737730 RANU/M

วท.ม. (โภชนศาสตร์)

คณะกรรมการควบคุมวิทยานิพนธ์: รัชนี คงคาฉุยฉาย, Ph.D. (FOOD SCIENCE AND TECHNOLOGY), พงศธร สังข์เผือก, D.Sc. (NUTRITION), ริญ เจริญศิริ, M.Sc. (NUTRITION AND DIETIETICS)

บทคัดย่อ

วัตถุประสงค์ของการศึกษาครั้งนี้ คือ การหาปริมาณแร่ธาตุชนิดต่างๆ (โซเดียม โพแทสเซียม แคลเซียม แมกนีเซียม เหล็ก ทองแดง และสังกะสี) โพลีฟีนอล แทนนิน คาเตชิน และไฟเตท และหาค่าสัดส่วนโมลาร์ของไฟเตทกับเหล็กและสังกะสี รวมถึงคำนวณปริมาณสารอาหารต่อหนึ่งหน่วยบริโภคของผลไม้สดและผลไม้กระป๋องที่นิยมรับประทานในประเทศไทย โดยผลไม้สด 37 ชนิดและ ผลไม้กระป๋อง 4 ชนิดซื้อมาจากตลาดสดและซุปเปอร์มาร์เก็ต 6 แห่ง ในเขตกรุงเทพมหานคร ในช่วงเดือนมกราคมถึงเดือนธันวาคม พ.ศ. 2549 จากการวิเคราะห์หาปริมาณโซเดียมและโพแทสเซียมด้วยเครื่อง Flame atomic absorption spectrophotometer และปริมาณแคลเซียม แมกนีเซียม เหล็ก ทองแดง และสังกะสีด้วยเครื่อง Inductively coupled plasma–optical emission spectrometry (ICP-OES) พบว่า ผลไม้เป็นแหล่งที่ดีของโพแทสเซียม โดยมีปริมาณโพแทสเซียมระหว่าง 28.30 ถึง 405.60 มิลลิกรัมต่อ 100 กรัมส่วนที่บริโภคได้ โดยผลไม้ที่มีปริมาณโพแทสเซียมสูง ได้แก่ กล้วยไข่ กล้วยหอม และทุเรียนชะนี ส่วนแร่ธาตุอื่นๆในผลไม้ พบว่ามีอยู่ปริมาณน้อย โดยในผลไม้ 100 กรัมส่วนที่บริโภคได้มีโซเดียม 0.59 ถึง16.32 มิลลิกรัม แมกนีเซียม 3.08 ถึง 25.21 มิลลิกรัม แคลเซียม 1.17 ถึง 22.09 มิลลิกรัม เหล็ก 0.08 ถึง 0.33 มิลลิกรัม ทองแดง 0.04 ถึง 0.27 มิลลิกรัม และสังกะสี 0.04 ถึง 0.28 มิลลิกรัม สำหรับปริมาณโพลีฟีนอล แทนนิน และคาเตชินในผลไม้ ซึ่งวิเคราะห์ด้วยเครื่อง Spectrophotometer พบว่ามีปริมาณอยู่ระหว่าง 4.67 ถึง 322.63 0.62 ถึง 43.37 และ 0.01 ถึง 21.44 มิลลิกรัมต่อ 100 กรัมส่วนที่บริโภคได้ตามลำดับ ผลไม้ที่มีโพลีฟีนอล แทนนิน และคาเตชินสูง คือ น้อยหน่าหนัง ส่วนการวิเคราะห์หาปริมาณไฟเตทในผลไม้โดยวิธี ion-pair reverse-phase chromatography พบว่ามีค่าระหว่าง 0.01 ถึง 6.02 มิลลิกรัมต่อ100 กรัมส่วนที่บริโภคได้ และผลไม้ที่มีไฟเตทสูงที่สุด คือ แก้วมังกร

เมื่อคำนวณหาปริมาณแร่ธาตุต่างๆ โพลีฟีนอล แทนนิน คาเตชิน และไฟเตท ในผลไม้ต่อหนึ่งหน่วยบริโภค พบว่าผลไม้มีโพแทสเซียมอยู่ระหว่าง 18 ถึง 325 มิลลิกรัม โดยแก้วมังกรมีปริมาณโพแทสเซียมต่อหนึ่งหน่วยบริโภคมากที่สุด คิดเป็นร้อยละ 9 ของปริมาณโพแทสเซียมที่แนะนำให้บริโภคต่อวัน และทองแดง 0 ถึง 0.3 มิลลิกรัม โดยลิ้นจี่ฮงอวยและอุ่นเขียว เป็นแหล่งที่ดีของทองแดง โดยหนึ่งหน่วยบริโภคให้ทองแดงคิดเป็นร้อยละ 10 และ 13 ของปริมาณที่แนะนำให้บริโภคต่อวัน ส่วนปริมาณแร่ธาตุอื่นๆในผลไม้ เมื่อคิดต่อหนึ่งหน่วยบริโภคมีปริมาณน้อย โดยมีโซเดียม 0 ถึง 11 มิลลิกรัม แมกนีเซียม 2 ถึง 27 มิลลิกรัม แคลเซียม 1 ถึง 21 มิลลิกรัม เหล็ก 0.1 ถึง 0.6 มิลลิกรัม และสังกะสี 0 ถึง 0.3 มิลลิกรัม ส่วนสตรอเบอรี่จัดว่าเป็นแหล่งของโพลีฟีนอลและแทนนิน (397.13 และ 28.49 มิลลิกรัมต่อหนึ่งหน่วยบริโภค) ในขณะที่มะเฟืองเป็นแหล่งของคาเตชิน (12.79 มิลิกรัมต่อหนึ่งหน่วยบริโภค) ส่วนปริมาณไฟเตทในผลไม้หนึ่งหน่วยบริโภค อยู่ระหว่าง 0.02 ถึง 7.22 มิลลิกรัม โดยผลไม้ที่มีปริมาณไฟเตทต่อหนึ่งหน่วยบริโภคสูงสุด คือแก้วมังกร และเมื่อคำนวณค่าสัดส่วนโมลาร์ของไฟเตทกับธาตุเหล็กและสังกะสี พบว่าค่าสัดส่วนของ Phy/Fe มีค่าน้อยกว่า 2.06 Phy/Zn มีค่าน้อยกว่า 4.20 และ Ca×Phy/Zn มีค่าน้อยกว่า 39

228 หน้า

CONTENTS

CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

FIGURE **Page**

LIST OF ABBREVIATIONS

AA	Flame atomic absorption spectrophotometer
BP	Blood pressure
Ca	Calcium
CBP	Calcium-binding protein
CKD	Chronic kidney disease
Cu	Copper
Cu^{1+}	Cuprous state
Cu^{2+}	Cupric state
°C	Degree of celsius
DMF	Dimethylformamide
ESRD	End-state renal disease
FCR	Folin-Ciocalteu's reagent
Fe	Iron
HCl	Hydrochloric acid
HPLC	High performance liquid chromatography
HT	Hypertension
ICP-OES	Inductively coupled plasma – optical emission spectrometry
INMU	Institute of Nutrition, Mahidol University
IP5	Inositol pentaphosphate
IP6	Inositol hexaphosphate
IZiNCG	The International Zinc Nutrition Consultative Group
K	Potassium
mEq/L	Milli – equivalent per liter
Mg	Magnesiun
mg	Milligram
mmHg	Millimeters of mercury
mmol/d	Milli – mole per day
Na	Sodium

LIST OF ABBREVIATIONS (Continued)

NaOH	Sodium hydroxide
NCDs	Non – communicable diseases
NCDs-related DALYs	Total disability – adjusted life years
NHNES III	The National Health and Nutrition Examination Surveys III
PTH	Parathyroid hormone
SOD	Superoxide dismutase
Thai-DRI	Thai Dietary Reference Intake
TRT	The Thailand Renal Replacement Therapy registry
Zn	Zinc

CHAPTER I
INTRODUCTION

Among the 58 million mortality in the world in 2005, non-communicable diseases (NCDs) ,e.g. Cardiovascular diseases, Cancer, Chronic respiratory diseases, Diabetes, kidney disease and other chronic disease were estimated to account for 35 million, which is 61% of total number of mortality in the global. The major of mortality (80%) from non-communicable diseases occur in developing countries. The mortality attributable to non-communicable diseases from 2005 to 2030 is expected to rise from 61% to 68%, while the share of communicable, maternal, perinatal and nutritional causes is expected to decrease from 30% in 2005 to 22% in 2030 and NCDs-related DALYs (Total disability-adjusted life years) loss from 9% in 2005 to 28% in 2030 (1). Cardiovascular diseases are a major cause of death and estimated to account for about 17.5 million deaths in 2005 (1) or about 14.3 million deaths each year (2, 3).

Moreover, hypertension disease can lead to sudden death and chronic diseases, e.g. cardiovascular disease, myocardial infraction, stroke, congestive health failure, and end-stage renal disease (ESRD) (4, 5). Data from The National Health and Nutrition Examination Surveys III (NHNES III) indicated that the prevalence of Hypertension (HT) in the U.S. adults increased from 24% in 1988-1991 to 28.7% in 1999-2000 (6). In Thailand, public health statistics from 1997 to 2004 showed that prevalence and mortality rate of HT were increasing every year (7-14). Recently, in 2004 the prevalence of Hypertension people was 389.3 per 100,000 population, increased 2 times when compare with that of 1999 (10-14). Furthermore, the prevalence of chronic kidney disease (CKD) has been reported in many countries. In USA, the Third National Health and Nutrition Examination Survey (NHANES III) showed 11% (19.2 millions) were diagnosed as CKD (15). The prevalence of CKD in the western part of Australia was 16% (16). In Singapore, a south-east Asian country, the CKD prevalence of 10.1% was reported (17). In Thailand, the Thailand Renal

Replacement Therapy (TRT) registry estimated that the prevalence of ESRD patients in Thailand was 1995 cases in 2000 and 13,597 cases in 2004 (18).

Thailand is one of the developing countries which economic structure has shifted from agriculture to industry and commercial. Social structure and lifestyle have been changed from a rural orientation to an urbanized society. Eating patterns have shifted from a traditional Asian diet, e.g. cereal-base, high fruits and vegetables, and low fat to a Westernized diet, e.g. increased consumption of animal products, high fats and sugars, and low fruits and vegetables. Lifestyle and eating patterns are important factors contributing to the increased prevalence of chronic, diet related diseases (19-21).

Fruits are a major part of daily consumption in both healthy and diseased people and have a variety of pleasant and attractive flavors. Many research have been shown that the substances or constituents such as phyto-nutrient with strong antioxidant capacity such as polyphenol, tannin, phytate, vitamins and minerals in fruits are more beneficial to human health and also contribute to the prevention of non-communicable diseases because they act as antioxidant (22, 23)

Several studies revealed that the high fruits and vegetables consumption can promote health and reduce a risk factor of chronic diseases (19-21). But the nutritive values of fruits in Thai food composition table have not been completely presented and some parts were taken from the foreign countries. Thus, some data that were used for calculation of the nutritive values may deviate from the actual value. Furthermore, the data of nutritive values had been analyzed very long ago. Although the data obtained from this study might be important information for physicians, dieticians, public health or even general consumers, essentially patients with hypertension, coronary heart disease and renal disease where proper selection of food is required. In additional, the data can be used to make up one portion of fruit which will be helpful either for people in normal condition or people in disease state to plan their own dietary consumption as well as to provide people's need for food and nutritional security.

CHAPTER II
OBJECTIVE

The objectives in This Study :

General objective:

To complete the database of nutritive values of fruits and fruit products commonly consumed in Thailand, especially minerals (sodium, potassium, calcium, magnesium, iron, copper, zinc), polyphenol, tannin, catechin and myo-inositol phosphates; penta and hexaphosphates (IP5 and IP6) and use them as database for physician, dieticians or even for consumers, especially patients with hypertension and chronic kidney disease or general consumer.

Specific objective:

1. To determine mineral contents (sodium, potassium, calcium, magnesium, iron, zinc and copper) in selected Thai fruits.
2. To determine polyphenol, tannin, catechin and myo-inositol phosphates; penta and hexaphosphates (IP5 and IP6) contents in selected Thai fruits.
3. To calculate molar ratio of phytate/iron, phytate/zinc, [calcium][phytate]/zinc in selected Thai fruits.
4. To approximate a food exchange list of fruit and classify the nutritive values as low, medium and high levels in order to recommend people who have a chronic disease especially hypertension and chronic kidney disease.

CHAPTER III
LITERATURE REVIEW

3.1 Sodium

3.1.1 Definition, function, absorption and excretion

Sodium is electrolyte that maintains equilibrium of osmosis, intracellular fluid, extra-cellular fluids, and interstitial fluids. Sodium is absorbed by active transport when dietary sodium is less than blood sodium and passive diffusion when dietary sodium becomes more than blood sodium, this processes usually have glucose as an enhancer. The most absorption of sodium occurs in jejunum and the least absorption occur in stomach. Sodium ion is an essential nutrient for many important functions in the body. Not only does sodium maintain cellular osmotic pressure and extracellular fluid volumes including blood, but it also is necessary for transmission of nerve impulses, muscle contraction, permeability of cell membranes (24, 25).

In a healthy individual, sodium balance is normally maintained inspite of a wide range of sodium intake by mean of renal, neural, and hormonal mechanisms involving the kidneys and adrenal glands (26). These elaborate controls facilitate the removal of sodium from the body when excess sodium is ingested, as well as the retention of sodium when an insufficient amount of this nutrient is consumed (27).

3.1.2 Foods source of sodium

Sodium in food can be from 3 sources including (i) from nature, (ii) from production process and (iii) added by individual during cooking and eating. Commonly source of sodium in foods is sodium chloride, with small amounts as sodium bicarbonate, sodium glutamate, and sodium citrate. These sodium salts are low in fresh vegetables and fresh fruits but high in cured meat products, processed foods, and canned vegetables.

3.1.3 Sodium and Health

3.1.3.1 Sodium and Hypertension

Overall the principle observations study in INTERSALT (28-30) were that (i) for individuals, a difference of 100 mmol/d (equivalent to 2,300 mg or 5.9 g sodiumchloride) in Na intake was associated with a difference of 3 to 6 mmHg in systolic BP; and (ii) for populations, a lower 100 mmol/d Na intake was associated with attenuation of the rise in systolic BP by 10 mmHg in person aged 25 to 55 years. In additional, the lower blood pressures by low Na dietary are more apparent in hypertensive than in nonhypertensive individuals. In a recent 18-month study, He et al (31) demonstrated that a net reduction (compare with the control group) of 3.3 mmHg and 1.7 mmHg for systolic and diastolic BP, respectively. Results form He et al (31) showed that low dietary Na intake significantly lower BP when compared with normal dietary Na intake.

3.1.3.2 Sodium and kidney disease

Sodium, as an extracellular electrolyte, helps regulate fluid balance. Filtration of sodium decreases in chronic kidney disease (CKD) patient (32, 33). Sodium intake control is initiated when fluid retention occurs. In patient with end-stage renal disease, the ability of the kidney is limited to excrete large sodium. So, sodium intakes are regulated in all patients to prevent extra-cellular over hydration leading to heart failure and hypertension. Sodium balance will be maintained on a daily intake of less than 2 g/day (32, 33).

3.1.4 Thai Dietary Reference Intake for sodium

Daily minimum requirement of sodium in the adult can be estimated from the amount needed to replace obligatory losses (sweat, urine and stool). However, sodium deficiency does not normally occur because sodium can found in all diets. Thai Dietary Reference Intake (DRI) provides the daily amounts of sodium for reference levels and guidelines to determine optimal sodium intake (34).

Table 1 Thai Dietary Reference Intake (Thai DRI) for sodium through the life cycle

Age group	DRI (mg/day)	
	male	Female
6 - 11 months	175 - 550*	175 - 550*
1 - 3 years	225 - 675	225 - 675
4 - 8 years	300 - 950	300 - 950
9 - 18 years	400 - 1600	350 - 1275
19 - 70 years	475 - 1475	400 - 1200
≥ 70 years	400 - 1200	350 - 1050
Pregnancy	-	+50 - 200
Lactation	-	+125 - 350

3.2 Potassium

3.2.1 Definition, function, absorption and excretion

Potassium is clearly essential to life, being the most abundant cation in human. In contrast to sodium, potassium is found at a much higher concentration inside a cell than outside.

It plays a critical role in maintaining membrane potential (35). The mechanism of potassium absorption is not clearly understood. Over 90% of ingested potassium is absorbed, and while the sites along the gastrointestinal tract at which this takes place have not been precisely identified, both the small intestine and the colon appear to play a role in this function. The usual daily load of potassium, including that in food and that resulting from cellular breakdown, is about 100 mEq/day. That amount of potassium, therefore, has to be excreted daily to maintain the total body potassium level. The excretions of potassium occur in kidney by urine and feces. The kidney's capacity to vary potassium excretion is profound. With chronic potassium depletion, urinary potassium concentration can be reduced to 5 mEq/L. As the potassium intake increases, the urinary potassium concentration can increase to a level of 100 mEq/L (36, 37).

3.2.2 Food source of potassium

Potassium is widely distributed in foods, especially in vegetables and fruits.

3.2.3 Potassium and Health

3.2.3.1 Potassium and Hypertension.

Both epidemiological and clinical studies have strongly suggested that an increase in K intake can decrease BP (38, 39).

A clinical study from Franzoni et al (38) demonstrated that supplement potassium aspartate 30 mmol/d in hypertensive subjects was significantly lower systolic and diastolic BP 12/8 mmHg. This was supported by the conclusion of meta-analysis of clinical trials that oral K supplement (60 to 120 mmol/d) lowered BP of 3.11 mmHg in systolic blood pressure and 1.97 mmHg in diastolic blood pressure (39). This supported that low potassium intake may play an important role in the genesis of high blood pressure.

3.2.3.2 Potassium and Kidney disease

Patients with Chronic renal failure (CRF) in the early stage would still have normal urine output, without edema. The kidney still disposes potassium. Thus, patient can still consume vegetables and fruits which are rich in potassium. However, in the end-stage of CRF, patients should be avoiding the food with high much potassium. If the level of potassium in blood is higher than 6 mEq/l, it will affect the muscle and eventually cause abnormal function. It may cause malfunction of the heart muscle and death in the patients (32, 33).

3.2.4 Thai Dietary Reference Intake for Potassium

Thai Dietary Reference Intake (DRI) provides the daily amounts of potassium for reference levels and guidelines to determine optimal potassium intake (34).

Table 2 Thai Dietary Reference Intake (Thai DRI) for potassium through the life cycle

Age group	DRI (mg/day)	
	Male	Female
6-11 months	925 - 1550	925 - 1550
1-3 years	1175 - 1950	1175 - 1950
4-8 years	1525 - 2725	1525 - 2725
9-18 years	1975 - 4500	1875 - 3600
19-70 years	2450 - 4200	2050 - 3400
≥ 70 years	2050 - 3400	1825 - 3025
Pregnancy	-	+350 - 575
Lactation	-	+575 - 975

3.3 Calcium

3.3.1 Definition, function, absorption and excretion

Calcium is the most abundant in the human body and most prevalent mineral ion. About 1 to 2% of normal adult body weight is calcium. It plays two physiological roles both structural and functional components in the body. In the role of structural component, calcium is an essential component for maintain cell membranes. In another role, it has a variety of biochemical and physiological process, including blood coagulation, neuromuscular excitability, cell membrane permeability, release of cell enzymes, signal transaction, and reproductive functions such as sperm motility and fertility of the ovum.

The absorption of calcium has two transport processes. One of transport process occurs in duodenum and proximal jejunum. This process involves a calcium-binding protein (CBP or calbindin) and is regulated by calcitriol ($1,25(OH)_2D_3$). Calcitriol is stimulated when calcium requirements are increased, especially calcium in diet less than 400 mg, conditions of growth, pregnancy and lactation. The other of transport processes occur in jejunum and ileum, is nonsaturable and passive, and appears to be paracellular (25). The enhance absorptions of calcium depending on a variety of factor such as an amount of vitamin D hormone, body need, high protein diet, presence of lactose in food, acidity of digestive mass and calcium-phosphorus balance (1:1 to 2:1).

In contrast, the inhibitors of absorption of calcium are vitamin D deficiency, excess protein, dietary fat, fiber, oxalic acid and phytic acid (40).

The excretion of calcium is in the feces, urine, and sweat. Calcium in the feces is mostly unabsorbed dietary calcium. Hormone and the composition of the diet influence the amount of calcium excreted in the urine. Protein, sodium, and some carbohydrates increase calcium excretion, whereas phosphorus decreases it. Unless sweating is extreme, little calcium is lost from the skin (41).

3.3.2 Food sources of calcium

Calcium can be obtained from animal or vegetable sources, but animal sources are more readily absorbed. Milk and milk products are the best animal sources of calcium, follow by sardines, oysters and salmon. In milk, calcium combined with lactose, which increases absorption. Good plant sources of calcium include beans, cauliflower, rhubarb and green leafy vegetables such as chard, kale and broccoli.

3.3.3 Calcium and Health

3.3.3.1 Calcium and Hypertension

Adequate intakes of calcium are thought to be decreasing hypertension. A dose-response relationship between calcium intake and blood pressure reduction was found in African American adolescents (42). One recent meta-analysis of 42 randomized, controlled calcium supplementation trials showed that blood pressure reduction is greatest in individuals consuming low dietary calcium (43).

3.3.3.2 Calcium and kidney disease

In patients with kidney disease, vitamin D cannot be activated and can lead to a low serum calcium level. When the serum calcium level drops, calcium is released from the bones because of the increased secretion of parathyroid hormone (PTH). PTH is secreted in an attempt to correct the calcium imbalance. This chain of events may lead to renal osteodystrophy, which is a major complication of end-stage renal disease. (44)

3.3.4 Thai Dietary Reference Intake for Calcium

The requirements of calcium at various stages of growth can changeable follow life span that increases during the spurt growth year of childhood and adolescence, and adults older than 51 years old. The estimates of daily amounts of calcium have been provided in Thai Dietary Reference Intake (DRI), were considered as a reference levels and used as guidelines to determine optimal calcium intake (34).

Table 3 Thai Dietary Reference Intake (Thai DRI) for calcium through the life cycle

Age group	DRI (mg/day)
6-11 months	270
1-3 years	500
4-8 years	800
9-18 years	1000
19-50 years	800
≥ 51 years	1000
Pregnancy and lactation	800

3.4 Magnesium

3.4.1 Definition, function, absorption and excretion

Magnesium is the fourth most common cation in the body and the second most common intracellular cation after potassium. Magnesium can divide into three major compartments of the body: about 65% in the mineral phase of skeleton, 34% in the intracellular space, and only 1% in the extracellular fluid. It is a prominent component in the intracellular compartment, an important regulator of the cellular processes, cofactor of more than 320 enzymatic reactions involving energy metabolism and nucleic acid synthesis (45). Moreover, it is involved in several processes, including hormone receptor binding and gating of calcium channels, transmembrane ion flux, regulation of adenylate cyclase, muscle contraction and neuronal activity, control of vascular tone, cardiac excitability and neurotransmitter release.

Absorption of magnesium occurs in small intestine. In health people, the levels of magnesium in plasma are remarkably constant, 1.7-2.4 mg/dl (0.7-1.0 mmol/l). Kidney is the primary regulator of magnesium balance. A filtration-reabsorption process is an

indispensable process for maintainable magnesium balance. In a 24 h period, about 3500 mg of magnesium is filtered at kidney and only 3-4% of this amount is excreted in the urine, or about 100 to 150 mg per day; an amount equal to that absorbed by the gastrointestinal tract each day (45). A volume of renal magnesium wasting depends on a renal defect, response of the kidney to a variety of systemic and local factors that increase magnesium losses.

Although no known hormonal factor is specifically involved in the regulation of magnesium metabolism, many hormones have an effect on magnesium balance and transport. A number of hormones, including parathyroid hormone and calcitonin, vitamin D, glucagons, antidiuretic hormone, aldosterone and sex steroids have been reported to influence magnesium balance. In addition, several studies have confirmed that insulin is a key hormone in the regulation of magnesium metabolism (46).

3.4.2 Foods source of Magnesium

The most concentrated sources of magnesium are nuts, dried legumes, whole grains, and certain shellfish, notably winkles and conch. Foods somewhat less concentrated but still high in magnesium are clams, muscles, crabs, and dark green leafy vegetables.

3.4.3 Magnesium and Health

3.4.3.1 Magnesium and Diabetes Mellitus

Magnesium and Diabetes is a strong relationship. Cytosolic free Mg is frequently low in diabetic patients (47). Intracellular free magnesium levels were closely and inversely related to the level of the fasting blood glucose (47). The study of Barbagallo *et* al., recently reported that hyperglycemia also increases intracellular free calcium content of cultured vascular smooth muscle cells, suggesting an ionic mechanism for the increased vasoconstriction present in chronic diabetic state (48). Addition, magnesium deficiency aggravates insulin resistance and predisposes diabetic subjects to cardiovascular diseases.

3.4.3.2 Magnesium and Hypertension

Magnesium ion is associated with the biochemical process of contraction, modulates vascular smooth muscle tone and contractility by affecting calcium ion concentrations and its availability at critical sites. Mg ions activity promote relaxation, offset calcium-related excitation- contraction coupling and maintenance of the resting cellular membrane potential, by competitively inhibiting Ca binding to calmodulin, and stimulating both plasma membrane and sarcoplasmic reticulum Ca ATPase (47, 49). Several studies have suggested that an inverse relation exists between magnesium intake and hypertension, lower dietary magnesium intake being associated with higher blood pressure (50, 51).

3.4.4 Thai Dietary Reference Intake for Magnesium

Thailand has a little data of magnesium intake so some data were taken from the foreign countries for the estimates of daily amounts of magnesium in Thai Dietary Reference Intake (DRI). It was considered as a reference levels and used as guidelines to determine optimal magnesium intake (34).

Table 4 Thai Dietary Reference Intake (Thai DRI) for magnesium through the life cycle

Age group	**DRI (mg/day)**	
	male	Female
6-11 months	30	30
1-3 years	60	60
4-8 years	80 - 120	80 - 120
9-18 years	170 - 290	170 - 250
≥ 19 years	280 - 320	240 - 260
Pregnancy and lactation	-	+30

3.5 Iron

3.5.1 Definition, function, absorption and excretion

Iron is an essential component of heme, several nonheme enzymes and cofactor enzymes. As a part of hemoglobin, heme is required for the transport of oxygen from

the lung to the tissues and is a component of myoglobin, nonheme is required for the storage of oxygen. A large proportion of body iron is classified as “functional iron” which is associated with energy metabolism. Functional iron accounts for about 70 % and 80 % of the total iron in adult males and females, respectively. Storage iron is found in the bone marrow and in the liver, where it is present as either ferritin or hemosiderins, which are large iron-protein complexes. The stored iron may be mobilized to maintain functional iron compound (26)

The absorption of iron from foods varies from about 3 to 40 %, depending on a variety of factors such as composition of meal, body iron store and acid in stomach (26, 27). Forms of iron in food greatly influence iron absorption (27).

Heme iron is derived from the hemoglobin and myoglobin in meat, poultry, and fish. The absorption of heme is constant and independent of meal composition (52). It is absorption as an iron-porplyrin complex into the mucosal cells. After heme iron enter cell, it is rapidly degraded by heme oxygenase, and the iron is released then enters the common intracellular iron pool (52).

Nonheme iron is present in plant sources. The absorption is mostly occurring in the duodenum because of the greater solubility of luminal iron in the proximal, more acid region of the small intestine (52). And the percentage of ingested nonheme iron that is absorbed depends on the quantity consumed, the iron nutritional status, and the presence of inhibitors or enhancers of iron absorption.

Iron is excreted from the body between 0.9 and 1.0 mg/day (12-14 mg/kg/day). The most of iron losses are via the gastrointestinal tract (approximately 0.6 mg). The skin losses of approximately 0.2 to 0.3 mg iron are due to desquamation of surface cells from the skin. Lastly, a very small amount, about 0.1 mg, is lost in the urine (26).

Table 5 Dietary factors that affect iron absorption.

Enhancers	Inhibitors
Vitamin C	Phytate
Acid in stomach	Lack of stomach acid
Heme iron	Oxalate
High body demand for red blood cells (blood loss, high altitude, physical training, pregnancy)	Tannins
	Excess of other minerals (Cu, Zn, Mn, Ca)
Low body iron stores	Full body iron stores
Meat protein factor	Some antacid

3.5.2 Foods source of iron

Dietary iron is presented in 2 forms; organic (heme) and inorganic (ferric and ferrous). Source of heme iron is meats, fish and poultry. Iron in meat product is absorbed up to 30%. Sources of nonheme iron include cereal products, vegetables and fruits are poorly absorbed.

3.5.3 Iron and Health

3.5.3.1 Iron and Kidney disease

Patients with end-stage renal disease are often anemic because they lose blood from hemodialysis treatment (32). Intravenous iron supplement was given during hemodialysis treatment. And supplement with synthetic erythropoietin to replace the nature hormone, which ESRD patients lack, has dramatically improved anemia typically seen in hemodialysis patients (33).

3.5.4 Thai Dietary Reference Intake for Iron

Iron is an important ion for every stages of growth. Thai Dietary Reference Intake (DRI) provides the daily amounts of iron for reference levels and guidelines to determine optimal iron intake (34).

Table 6 Thai Dietary Reference Intake (Thai DRI) for iron through the life cycle

Age group	DRI (mg/day)	
	Male	Female
6-11 months	9.3*	9.3*
1-3 years	5.8	5.8
4-8 years	6.3 - 8.1	6.3 - 8.1
9-18 years	11.8 - 16.6	19.1 - 28.2
19-50 years	10.4	24.7
≥ 51 years	10.4	9.4
Pregnancy	-	+60 [b]
Lactation	-	+15 [c]

b Pregnancy should be receive iron tablet for 60 mg per day

c Lactation should be receive iron from foods for 15 mg per day

3.6 Copper

3.6.1 Definition, function, absorption and excretion

Copper, acts as an enzyme cofactor and as an allosteric component of enzymes, is found in the body in either of two valence states, cuprous state (Cu^{1+}) or cupric state (Cu^{2+}). The copper content of the human adult body is on the order of 50 to 110 mg. Copper in plasma is found ceruloplasmin form, also known as ferroxidase I, is responsible for the oxidation of minerals. Ceruloplasmin also scavenges oxygen radicals to protect cells and modulates the inflammatory process as an acute-phase protein. Copper in erythrocytes, about 60%, is found with superoxide dismutase (SOD). Copper (Cu^{2+}) is found at the enzyme's active site, where the superoxide substrate binds to the enzyme.

Copper in foods, acts as protein component, is bound to organic compound. Gastric hydrochloric acid and pepsin facilitate the release of bound copper in the stomach. Copper is absorbed throughout the small intestine, especially duodenum. From intestine cell, copper is transported to the liver bound loosely to albumin. Copper is storage at liver, which is thought to be bound to metallothionein (53). And copper is excreted via the feces, urine or sweat. Most absorbed copper (2 mg) is

secreted by the liver into the bile for excretion in the feces. Only a little amount of copper (10-50 µg) is excreted through the kidney in urine. And, a little amount of copper (50-100 µg) is excreted via skin (53).

3.6.2 Food sources of Copper

The richest sources of copper are organ meats and shellfish, especially oysters. Plant food sources include nuts, seeds, legumes, dried fruits and a few select vegetable are rich source of copper.

3.6.3 Copper and Health

3.6.3.1 Copper and Diabetes Mellitus

Under conditions of experimental dietary Cu deficiency in humans, altered glucose metabolism has been noted in some, but not all studies. The study of Kumar *et al.*, 2004 (54) found that abnormal glucose homeostasis is not a common characteristic of infants with Menkes'disease, or human with Zn excess-induced Cu deficiency. While altered Cu metabolism can directly or indirectly alter glucose homeostasis, conversely, diabetes can perturb Cu metabolism.

3.6.4 Thai Dietary Reference Intake for Copper

The requirement of copper at various stages of growth is low. Thai Dietary Reference Intake (DRI) (34) has been provided the daily amounts of copper for childhood and adolescence, and adults older than 51 years old as seen in Table 7

Table 7 Thai Dietary Reference Intake (Thai DRI) for copper through the life cycle

Age group	DRI (µg/day)	
	Male	Female
6 - 11 months	220*	220*
1 - 3 years	340	340
4 - 8 years	440	440
9 - 18 years	700 - 890	700 - 890
19 - 50 years	900	900
≥ 51 years	900	900
Pregnancy	-	+100
Lactation	-	+400

3.7 Zinc

3.7.1 Definition, function, absorption and excretion

Zinc, a constituent of enzymes involved in the most major metabolic pathway, is an essential element for plants, animals and humans. Zinc is present in all organs, tissues and fluids of the body. The total body content of zinc in the adult human is 1-2g. About 60% of the total zinc content is found in skeletal muscle.

The absorption of zinc occurs in the intestinal, especially jejunum, by via a carrier-mediated transport process and by passive diffusion. Zinc is transported in blood bound to albumin, α_2 – macroglobulin and amino acids. Zinc is excreted from the body via urine, skin and intestine with total daily losses in the order of 1.5-3 mg. Under normal dietary condition urinary excretion is approximately 0.5 mg/d. The homeostasis of zinc is maintained by changes in fractional absorption and intestinal endogenous excretion over a large range of intakes. Under low and excess intake conditions, the urinary and skin excretion is a major function to maintain homeostasis. (26)

3.7.2 Food sources of zinc

Categorization of the zinc contents of foods is difficult. In general, meat, eggs, shellfish, and some vegetables are high in zinc. In contrast, milk, fruits, and other

vegetables are reported to be lower in zinc content. Furthermore, zinc content in food is depended on zinc in the soil.

3.7.3 Zinc and Health

3.7.3.1 Zinc and Kidney disease

A serum zinc concentration is frequently low in chronic kidney disease and urinary zinc excretions are increased. The causes of Zn deficiency in kidney disease are not clear. Decreased dietary Zn intake and intestinal absorption, increased endogenous Zn secretion, and increased urinary Zn excretion (as in the nephrotic syndrome and in renal transplant recipients) all may contribute to altered Zn metabolism. (55) Additional, peritoneal dialysis patients can lead to a zinc deficiency. (32, 33)

3.7.4 Thai Dietary Reference Intake for Zinc

The requirement of zinc for Thai people is based on the standard of the International Zinc Nutrition Consultative Group (IZiNCG). The committee based zinc recommendation on the intake needed to maintain balance as well as on estimates of zinc absorption and body losses of zinc for every stage of life (34).

Table 8 Thai Dietary Reference Intake (Thai DRI) for Zinc through the life cycle

Age group	**DRI (mg/day)**	
	Male	Female
6 - 11 months	3	3
1 - 3 years	2	2
4 - 8 years	3 - 4	3 - 4
9 - 18 years	5 - 9	5 - 7
19 - 50 years	13	7
≥ 51 years	13	7
Pregnancy and lactation	-	+1- 2

3.8 Dietary factors affect mineral absorption

3.8.1 Polyphenol

Phenolic compounds constitute one of the most numerous and widely distributed groups of substances in the plant kingdom, with more than 8,000 phenolic structure currently known. Phenolic compounds are products of the secondary metabolism in plants derived from phenylalanine and, to a lesser extent in some plants, also from tyrosine. The expression “phenolic compounds” embraces a considerable range of substances that possess an aromatic ring bearing one or more hydroxyl substituents. The structure of natural phenolic compounds varied from small monomeric phenolic acid, such as gallic acid, caffeic acid, to large polymerized polyphenolic molecules, such as condensed tannins.

Tannins are polyphenols capable of precipitating proteins from aqueous solution and are widely distributed in plants. They are found in especially high amounts in food grains such as sorghum, millets, barley, dry beans, faba beans, and other legumes. Fruits such as apples, bananas, blackberries, cranberries, cranberries, grapes and strawberries are also certainly an appreciable quantity of tannins. Tannins can be classified into two categories: hydrolyzable and nonhydrolyzable or condensed tannins (56). Hydrolyzable tannins contain a central core of polyhydric alcohol such as glucose, and hydroxyl groups, which are esterified either partially of wholly by gallic acid (gallotannins) or hexahydroxydiphenic acid (ellagitannins). Condensed tannins (e.g. catechin) are mainly the polymerized products of flavan-3-ols and flavan-3,4-diols, or a mixture of the two. Condensed tannins are widely distributed in fruits, vegetables, forage, plants, cocoa, and certain food grains, such as legume and sorghum. Both categories have been shown to have an inhibitory effect on nonheme iron absorption (57).

3.8.2 Phytate

Phytate (*myo*-inositol hexaphosphate) is the principal storage form of phosphorus in many plant tissues. It typically represents more than 75% of the total phosphorus in cereals and other seed crops. Phytate is a strong chelator of cations and binds minerals such as calcium, magnesium, zinc and iron, making them unavailable for absorption in the human intestine (58).

In terms of human health, dietary phytate might have both negative and positive roles. Although, phytate can decrease mineral bioavailability and can contribute to mineral deficiency in populations in the developing world that consume rice, grains and cereal as staple foods, recently studies showed that dietary phytate might also have beneficial health effects, for example as an anti-cancer and antioxidant (59, 60). The negative effects of dietary phytate have the greatest impact on youth and growth in the developing world, whereas the positive effects of phytate are interested in the pathologies of aging such as oxidative damage and cancer in the developed world.

CHAPTER IV
MATERIALS AND METHODS

4.1 Sample Collection

Thirty-seven varieties of fresh fruits and fruit products were bought from six representative markets and supermarkets in Bangkok area during from January to December 2006. At each market, 2- 4 kg samples were purchased from three representative outlets. Single composite sample were prepared by combining about 600 g of homogenized single sample of the same variety from three representative outlets and homogenized again to obtain uniform single composite sample from 1 representative market. Fruit products (fruits in syrup; cans) were bought for six brands per each from supermarket in Bangkok. The single composite of fruits in syrup were prepared by combining of the three cans each fruit product and homogenized to obtain uniform single composite sample from 1 brand. The information of fresh fruit and fruit products commonly consumed by Thai people is showed in table 9 and 10.

Table 9 Fruits commonly consumed in Thailand (61)

English name	Thai name	Scientific name
Apple		*Pyrus malus, Borkh.*
Fuji variety (not peeled)	Apple-fu-ji	
Granny Smith variety (peeled)	Apple- khiaw	
Banana (peeled)		
Kluay-hawm variety	Glooway-hawm	*Musa sp.*
Kluay-kai variety	Glooway-kai	*Musa sapientum;Linn*
Kluay-nahmwah variety	Glooway-nahm-wah	*Musa sapientum.*

Table 9 Fruits commonly consumed in Thailand (continued) (61)

English name	Thai name	Scientific name
Chinese pear		*Pyrus communis*
Hawm variety	Salee-hom	
(not peeled)	Salee-namphung	
Namphung variety		
(peeled)		
Dragon fruit (peeled)		*Hylocereus spp.*
Vietnam variety	Gaewmuanggorn	
Durian (peeled)		*Durio spp.*
Chanee variety	Thurian-chanee	
Mawntong variety	Thurian-mawntong	
Grape (not peeled)		*Vitis vinifera, L.*
Green variety	A-ongn	
Guava (not peeled)		*Psidium guajava*
Pan-seetong variety	Farang	
Jackfruit (peeled)	Khanun	*Artocapus heterophylla*
Longan (peeled)	Lamyai –kalokbew	*Euphoria longana,*
Kalokbew variety		*Lamk.*
Longkong (peeled)	Long-gong	*Lansium domesticum*
		Corr
Lychee (peeled)		*Litchi chinensis, Sonn.*
Hohnghooway variety	Linchi-hong-houy	
Jackkrapat variety	Linchi- Jackkrapat	
Mango (peeled)		*Mangifera indica*
Kheosawoei variety	Mamuang- kheosawoei	
(unripe)		
Nahmdawgmai variety	Mamuang-nahm-dawgmai	
(ripe)		
Rad variety (unripe)	Mamuang-rad	

Table 9 Fruits commonly consumed in Thailand (continued) (61)

English name	Thai name	Scientific name
Mangosteen (peeled)	Mangkhut	*Garcinia mangostana*
Orange (peeled)		*Citrus sinesis Osb.*
Clementine variety	Som-cheang	
Sai-nuhm-phung variety	Somsai-nahmphung	
Papaya (ripe) (peeled)	Malagor- khakdahm	*Carica papaya, Linn.*
Khak-dahm variety		
Pineapple (peeled)	Sapparot-sriracha	*Ananas comosus, Merr.*
Sri-ra-cha variety		
Pomelo (peeled)		*Citrus maxima, Merr.*
Khao-nahm-peung variety	Som-o-Khaonahmpeung	
Tongdee variety	Som-o- Tongdee	
Rambutan		*Nephelium lappaceum,*
Rong-rean variety	Ngor-rohngrain	*Linn.*
Rose apple (not peeled)		*Syzygium samarangense*
Toon-klow variety	Chomphu-toolgaow	
Tub- tim-jun variety	Chomphu-tuptimjun	
Salacca (peeled)	Sala	*Salacca sp.*
Sapodilla (peeled)	Lamut	*Achras sapota, L.*
Star fruit (not peeled)	Mafuong	*Averrhoa carambola*
Strawberry (not peeled)	Sa-to-bo-ree	*Fragaria spp.*
Sugar apple (peeled)		*Auona sguamosa*
Nahng variety	Noi-na- nahng	
Watermelon (peeled)		*Citruluss vulgalis,*
Jin-trarah variety (red color)	Taeng mo- Jintrarah (red color)	*Schrad.*
Jin-trarah variety (yellow color)	Taeng mo -Jintrarah (yellow color)	

Table 10 Fruit products commonly consumed in Thailand (61)

Fruits	Thai name
Fruits in Syrup	
Fruit cocktail or fruit salad *	Fut-sa-lad
Longan	Lum-yai
Lychee	Lin-chi
Rambutan	Ngor

* Fruit cocktail in syrup are containing grape, guava, papaya, pineapple, rambutan, toddy palm and tangerine.

4.1.1 Sample preparation

Before analysis, all samples were washed with tap water several times to ensure that all contaminants were removed and rinsed again with deionized water. They were then individually prepared using common household practice. The edible portions of each single sample was separated and homogenized by the home-use electric blender (Cucina HR1791/6, PHILIPS). The homogenized samples were divided into 2 portions. One portion was analyzed as fresh sample for mineral analysis and other portion was freeze dried (Heto model PL 9000-50), before polyphenol, tannin and phytate analysis. Exception, the moisture contents was analyzed on the same day of sample preparation.

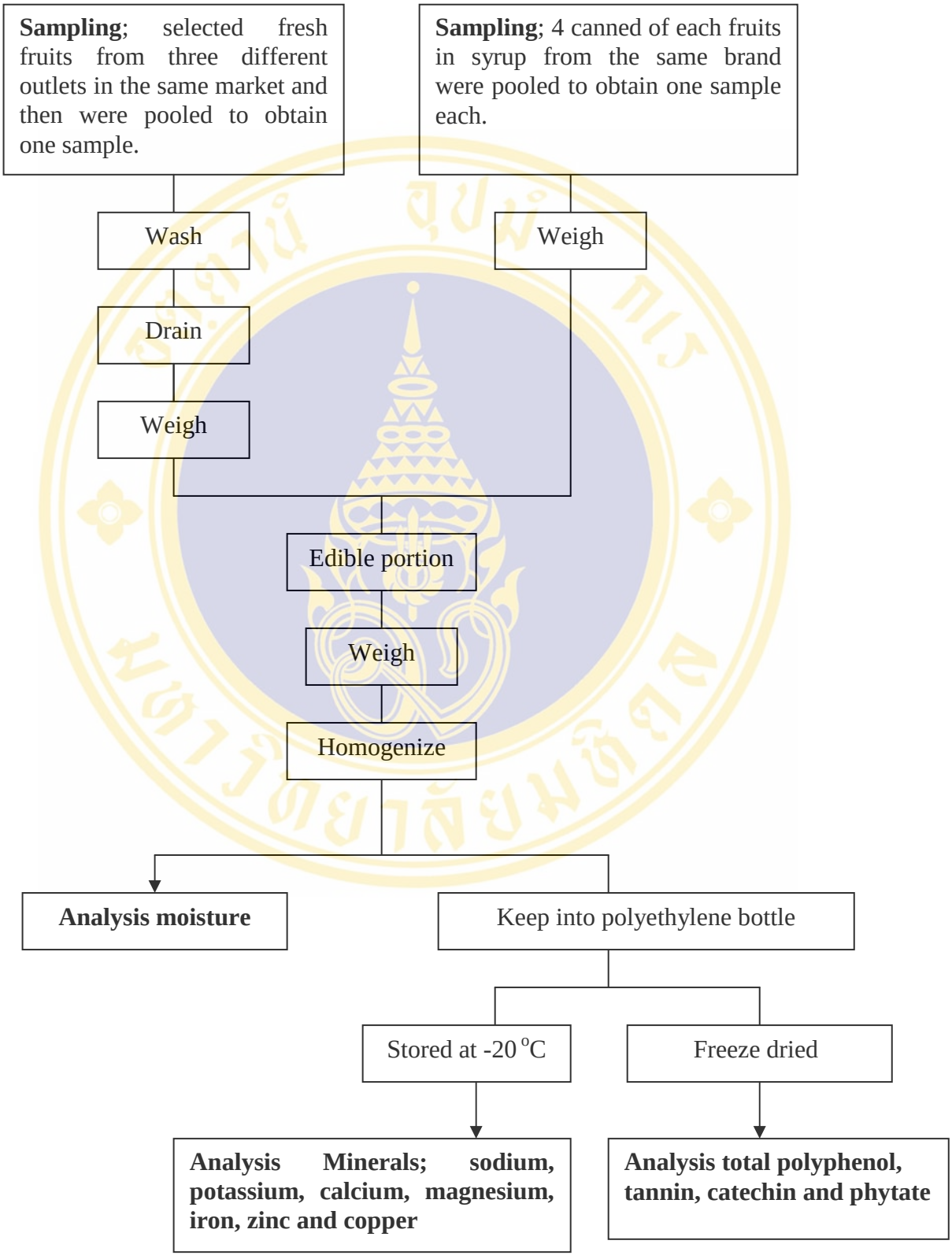


Figure 1 Sample preparation

4.2 Chemical Analysis

All fruits sample in present study were analyzed in duplicate for moisture, sodium, potassium, calcium, iron, zinc, magnesium, polyphenol, tannin, catechin and phytate (IP5 and IP6) contents.

4.2.1 Moisture Determination

Moisture content was determined by drying the sample in hot air oven at 100 $\pm$ 5 °C until constant weight was obtained (AOAC; 920.151, 2000). Moisture in the sample was estimated from the weight loss from drying under controlled temperature in an air oven. It is expressed in g per 100 g sample. As seen in appendix A (62)

4.2.2 Sodium and Potassium Determination

The samples were ashed in a muffle furnace at 550°C and ash solution was prepared by dry ashing (AOAC; 930.30, 2000) as showed in appendix B (62). The sodium and potassium contents of all the fruits samples were determined using flame atomic absorption spectrophotometer (Spectr AA-20). The instrument parameters such as wavelength, slit width and air-acetylene flow rate that are appropriate for each element was selected by according to a manual of analytical method for flame spectroscopy (Varian Techtron Pty, Ltd, Springvale, Australia 1979) as showed in appendix C (63, 64)

4.2.3 Calcium, Magnesium, Iron, Copper and Zinc Determination

Calcium, magnesium, iron, zinc and copper was determined in duplicate with inductively coupled plasma – optical emission Spectrometry (ICP-OES) after digestion in concentration nitric acid and perchloric acid at a 5:1 ratio in a hot-air oven at 100 to 120°C as showed in appendix D (65)

4.2.4 Tannin and Catechin assay

Tannin and catechin contents in each sample were determined by extracting with 50% dimethylformamide (DMF; Carloerba reagent # 444923) in 1 M acetate buffer

pH 4.4 and determining the absorbance at 578 and 680 nm in a spectrophotometer according to the method of Brune *et al*., 1991. Five standard dilution of tannic acid (# T-0125, sigma Chemical Co., St, Lois, MO) and catechin (# C-1788, sigma Chemical Co., St, Lois, MO) were prepared at concentrations between 25 to 400 µg/ml. The extracted solution was used as a blank to correct for any pigmented in the fruit sample. Tannin content was expressed in mg/100g of tannin equivalent as seen in appendix F (66).

4.2.5 Determination of total polyphenol content

Total phenolic content was determined by the Folin-Ciocalteu method (66). ***In briefly***; weigh about 2.0 g for fresh sample and lyophilized sample into a 125-mL volumetric flask and 25 mL of 50% dimethyformamide (DMF) (Carloerba reagent # 444923) in 1M acetate buffer pH 4.4 was added, then mixing and shaking for 16 hrs (Gyrotary water bath shaker model G76, USA). Afterwards, the mixtures were filtered with No. 42 filter paper (Whatman) and diluted the clear extract solutions with water. Then 25 µL of each diluted extract solution or standard were applied to 96 well microplate well and immediately added 125 µL of 10% FCR (Folin-Ciocalteu's reagent; Merck # 109001) in each well. One minute after adding 10% FCR, the 100 µL of 0.5 M sodium hydroxide (NaOH) (Merck # 106498) was added and kept in room temperature for 15 minute. The total phenolic contents in each well was read at 750 nm by the microplate reader (Microplate Photometer type "SUNRISE'' TECAN REMOTE CONTROL, AUSTRIA/EUROPE). Gallic acid monohydrate (Riedel-deHaen # 27645) was used as the standard calibration curve and total phenolic content of the sample was expressed as gallic acid equivalents (GAE) per 100 g sample (Appendix E)

4.2.6 Phytate (IP5 and IP6) Determination

Phytate (inositol pentaphosphate (IP5) and inositol hexaphosphate (IP6) contents were determined according to the method of Hotz and Gibson, 2001 (67). The homogenized samples were lyophilized (Heto model PL 9000-50) and then were ground in a coffee grinder (Kenwood CG 100). Grounded samples, approximately 0.5 g, were extracted with 5 ml of 0.67 M HCl for 30 min in an ultrasonic bath (Model

1510E-MT Bransonic). Following centrifugation at 3000 rpm, 10 min; Himag centrifuge CR5B2 Hitachi, the supernatants were removed and diluted with 22.5 ml of deionized water. The solutions were then applied into an anion exchange column (WAT023620, Sep-Pak Vac 1 cm^3 Water Accell Plus QMA,Water, Milford, MA) and inositol phosphates were eluted with 4 ml of 2 M HCl and evaporated to dryness at 40°C in a centrifuge evaporator (Model CVE-2000;EYELA, Tokyo Rikakikai Co., Ltd). The residues were dissolved in 1 ml of deionized water and analysis of IP5 and IP6 were performed by reverse phase HPLC using a C18 column (Atlantis dC18, 5µm, 4.6 x 150 mm) and mobile phase of methanol: H_2O in ratio 3:2 at a flow rate of 0.8 ml/min at 40°C. Eluted inositol phosphates were detected. Eluted inositol phosphates were detected by a refractive index detector (Waters IR 2414) as showed in Appendix G

The molar ratio of phytate / iron, phytate / zinc and phytate × calcium / zinc formula was calculated by following formula:

$$\text{Phytate : iron molar ratio} = \frac{\text{mg phytate/ g sample / 660 (MW)}}{\text{mg iron / g sample / 55.8 (AtW)}}$$

$$\text{Phytate : zinc molar ratio} = \frac{\text{mg phytate/ g sample / 660 (MW)}}{\text{mg zinc / g sample / 65.4 (AtW)}}$$

$$\text{Phytate} \times \text{calcium / zinc molar ratio} = \frac{\text{mg calcium}}{\text{40.1 (AtW)}} \times \frac{\text{mg phytate/ g sample / 660 (MW)}}{\text{mg zinc / g sample / 65.4 (AtW)}}$$

4.3 Calculation for one portion of fruit

The amount of nutritive value each kind of fresh fruits and fruits in syrup was calculated for one portion by following the food exchange lists that one portion of fruit is equal to 15 g of carbohydrate (68) and then Food Composition Table (69) was used to calculate the weight of each fruit per one portion.

4.4 Quality Control System

In each set of analysis, the quality of minerals, phytate, polyphenol and tannin were controlled by simultaneous analysis of in-house control materials which

consisted of black rice flour for phytate, polyphenol and tannin, and soybean flour for mineral analysis (sodium, potassium, magnesium, iron, zinc and copper) respectively. The assigned value was developed from 10 values of content for phytate polyphenol, tannin and minerals preparing the quality control chart of analysis. The accepted value of each nutrient of control sample was within mean ± 2 standard deviation.

4.4 Statistical Analysis

The determinations of minerals (sodium, potassium, calcium, magnesium, iron, copper and zinc), polyphenol, tannin, catechin and myo-inositol phosphates; penta and hexaphosphates (IP5 and IP6) in fresh fruits and fruit products were reported in term of mean value ± standard deviation. The nutritive values were classified as low, medium and high levels by the Quartile deviation and Stem and leaf. Using SPSS for Window version 13 software program (SPSS Inc, Chicago, Illinois, USA) preformed all computations.

CHAPTER V
RESULTS

5.1 Moisture content analysis

The moisture contents of edible portion of fresh fruits and fruits in syrup are shown in Table 11. The moisture contents of fresh fruits ranged from 66.81 to 91.48 % while the moisture contents of fruits in syrup ranged from 77.27 to 79.32 %. The highest moisture contents of fresh and canned fruits were found in watermelon (91.48%: Jin-trarah variety yellow) and the lowest was found in durian (66.81%: Chanee variety). The moisture contents were classified into three levels by the Quartile deviation, particularly in high level (more than 87.56 %), medium level (78.91 to 87.56 %) and low level (less than 78.91 %). High moisture content of fresh and canned fruits was found in orange (Clementine), pomelo (Khao-nahm-peung and Tong-dee varieties), watermelon (Jin-trarah variety, red), rose apple (Tub-tim-jun variety), star fruit, ripe papaya (Khak-dahm variety), strawberry, rose apple (Toon-klow variety) and watermelon (Jin-trarah variety, yellow). Medium level was found in longan in syrup, mango (unripe Kheosawoei variety), rambutan in syrup, longan (Kalokbew variety), mango (ripe Nahmdawgmai variety), salacca, mangosteen, longkong, rambutan (Rong-rean variety), lychee (Hohnghooway variety), mango (unripe Rad variety), lychee (Jackkrapat variety), grape (Green variety), pineapple (Sri-ra-cha variety), dragon fruit (Vietnam variety), apple (Fuji variety), chinese pear (Hawm variety), orange (Sai-nuhm-phung variety), apple (Granny Smith variety), chinese pear (Namphung and variety) and guava (Pan-seetong variety). Low level of moisture content was found in durian (Chanee variety), ripe banana (Nahm-wah variety), durian (Mawntong variety), ripe banana (Kai variety), jackfruit, sugar apple (Nahng variety), ripe banana (Hawm variety), sapodilla, lychee in syrup and fruit salad.

Table 11 Moisture content in fresh and fruit in syrup[1] (%)

English name (fresh fruit)	Variety	Local Thai name	Moisture (%)	N
Apple	Fuji	Apple	85.12 ± 2.30	6
	Granny Smith		86.03 ± 1.05	6
Banana (ripe)	Hawm	Kluay-hawm	75.51 ± 1.64	6
	Kai	Kluay-khai	71.63 ± 1.84	6
	Nahm-wah	Kluay-nahmwah	67.06 ± 1.90	6
Chinese pear	Namphung	Salee-namphung	86.24 ± 0.90	6
	Hawm	Salee-hom	85.41 ± 0.55	6
Dragon fruit	Vietnam	Keawmungkon	84.95 ± 0.66	6
Durian	Chanee	Thurian-chanee	66.81 ± 3.78	6
	Mawntong	Thurian-mawntong	70.90 ± 4.36	6
Grape	Green	A-ongn	82.55 ± 2.62	6
Guava	Pan-seetong	Farang	87.47 ± 1.39	6
Jack fruit		Khanun	74.08 ± 1.82	6
Longan	Kalokbew	Lam-yai -kalokbew	79.83 ± 0.75	6
Longkong		Long-gong	80.58 ± 0.44	6
Lychee	Hohnghooway*	Lin-chi-hohnghooway	81.30 ± 0.70	5
	Jackkrapat	Lin-chi- Jackkrapat	82.50 ± 1.00	6
Mango	Kheosawoei (unripe)	Ma-muang-kheosawoei	79.32 ± 1.65	6
	Nahm dawg mai (ripe)	Ma-muang-nahm dawg mai	80.05 ± 1.94	6
	Rad (unripe)	Ma-muang-rad	82.41 ± 1.76	6
Mangosteen		Mang-khut	80.19 ± 1.33	6

Table 11 Moisture content in fresh and fruit in syrup[1] (%) (Continued)

English name (fresh fruit)	Variety	Local Thai name	Moisture (%)	N
Orange	Clementine	Som-cheng	87.64 ± 1.65	6
	Sai-nuhm-phung	Som-sai nahm phung	85.89 ± 1.15	6
Papaya (ripe)	Khak-dahm	Ma-la-gor	89.73 ± 0.65	6
Pineapple	Sri-ra-cha	Sapparot-sri-ra-cha-	84.88 ± 1.02	6
Pomelo	Khao-nahm-peung	Som-O- Khao-nahm-peung	88.20 ± 2.00	6
	Tong-dee	Som-O- Khao-Tongdee	88.74 ± 0.60	6
Rambutan	Rong-rean	Ngor-rohng-rain	80.80 ± 2.83	6
Rose apple	Toon-klow	Chomphu- Toon-klow	90.96 ± 1.44	6
	Tub- tim-jun	Chomphu-tub-tim-jun	88.95 ± 0.64	6
Salacca		Sa-la	80.10 ± 0.43	6
Sapodilla		La-mut	75.53 ± 1.12	6
Star fruit		Ma- fuong	89.20 ± 0.43	6
Strawberry		Sa-to-bo-ree	89.55 ± 2.47	6
Sugar apple	Nahng	Noi-na-nahng	74.11 ± 1.58	6
Watermelon	Jin-trarah (red color)	Taeng Mo Jin-trarah (red color)	88.83 ± 2.02	6
	Jin-trarah (yellow color)	Taeng Mo Jin-trarah (yellow color	91.48 ± 1.31	6

Table 11 Moisture content in fresh and fruit in syrup[1] (%) (Continued)

English name (Fruits in syrup)	Local Thai name	Moisture (%)	N
Fruit salad*	Fut-sa-lad	78.77 ± 0.67	2
Longan in syrup	Lam-yai	79.04 ± 2.29	6
Lychee in syrup	Lin-chi	77.27 ± 1.38	6
Rambutan in syrup	Ngor	79.32 ± 2.11	6

[1]Data were reported as a mean ± SD of duplicate analysis (n=6)
With exception * n=5, ** n=2

5.2 Macro-mineral Content Analysis

The macro-elements content; sodium (Na), potassium (K), calcium (Ca) and magnesium; (Mg) of fresh fruits and fruits in syrup are shown in Table 12 (per 100 g dry wt), Table 13 (per 100g edible portion) and Table 14 (per one portion). Data analysis of macro-minerals all fresh fruits and fruits in syrup are wildly varied among different varieties of fruits.

5.2.1 Sodium content in fresh fruits and fruits in syrup

Sodium contents of fresh fruits and fruits in syrup are reported in mg/100 g dry weight as showed in Table12 and mg/100 g edible portion as showed in Table 13. A wide variation of fresh fruits and fruits in syrup ranged from 2.83 to 69.80 mg/100 g dry wt. Comparison among the sodium content of all fresh fruit varieties of this study was found that the highest source of sodium found in pomelo (Tongdee variety; 69.80 mg/100 g dry wt or 7.86 mg/100g edible portion). According to Quartile deviation, the concentrations of sodium are categorized into three levels, particularly in high (more than 36.58 mg/100 g dry wt), medium (14.66-36.58 mg/100 g dry wt) and low (less than 14.66 mg/100 g dry wt). The result showed that high concentration of sodium (36.62 to 66.69 mg/100g dry wt or 6.39 to 16.32 mg/100g edible portion) was found in grape (Green variety), orange (Sai-nuhm-phung variety), lychee in syrup, watermelon (Jin-trarah variety, red), guava (Pan-seetong variety), rose apple (Toon-klow, Tub- tim-jun varieties), longan (Kalokbew variety), pomelo (Khao-nahm-peung

variety) and sapodilla. Medium level ranging from 14.7 to 36.44 mg/100 g dry wt or 2.85 to 3.11mg/100g edible portion was found in longkong, orange (Clementine variety), rambutan (Rong-rian variety), ripe banana (Hawm variety), apple (Granny Smith variety), fruit salad, jack fruit, lychee (Hohnghooway variety), mango (unripe Rad variety), ripe banana (Kai variety), pineapple (Sri-ra-cha variety), dragon fruit (Vietnam variety), star fruit, ripe papaya (Khakdahm variety), chinese pear (Namphung variety), salacca, strawberry, chinese pear (Hawm variety), rambutan in syrup and watermelon (Jin-trarah variety, yellow). Low level (less than 14.64 mg/100 g dry wt or 2.56 mg/100g edible portion) of sodium was found in unripe mango (Kheosawoei variety), sugar apple (Nahng variety), durian (Mawntong variety), longan in syrup, mangosteen, apple (Fuji variety), durian (Chanee variety), ripe mango (Nahm-dawg-mai variety), ripe banana (Nahm-wah variety) and lychee (Jackkrapat variety).

The amount of sodium content of all the samples was calculated for one portion by based on one portion of food exchange list (68) which categorized the selected fruits of this study containing sodium less than 1 mEq (23 mg) as low value, 1-5 mEq (23 – 115 mg) as medium value and more than 5 mEq (more than 115 mg) as high value. Analysis data revealed that sapodilla was the highest in content of sodium (11 mg/portion). According to food exchange list, one portion of all samples in this study contained sodium less than 1 mEq (less than 23 mg/potion). It means fresh fruits or fruits in syrup in this study are poor sources of sodium as show in Table 14.

Table 12 Macro-mineral contents in fresh fruits and fruits in syrup[1]

English name (Fresh fruits)	Variety	Macro-mineral contents (mg/100g dry wt.)				N
		Sodium	Potassium	Calcium	Magnesium	
Apple	Fuji	11.93 ± 14.10	196.60 ± 50.30	25.46 ± 3.46	23.83 ± 4.40	6
		(0.00 - 3.14)	(121.74 - 244.16)	(21.71 - 30.78)	(20.23 - 32.19)	
		5.56	221.71	24.57	22.62	
	Granny Smith	17.42 ± 14.00	210.86 ± 157.53	34.28 ± 5.23	29.47 ± 2.13	6
		(2.80 - 41.20)	(75.49 - 502.71)	(26.92 - 39.66)	(25.56 - 31.71)	
		15.80	161.39	35.37	29.64	
Banana (ripe)	Hawm	16.89 ± 13.62	1416.82 ± 237.13	11.00 ± 3.35	87.59 ± 4.16	6
		(4.29 - 34.91)	(1043.81-1686.44)	(7.76 - 17.10)	(81.63 - 94.22)	
		11.37	1456.19	9.84	87.44	
	Kai	23.63 ± 11.57	1091.88 ± 264.63	7.17 ± 1.88	79.40 ± 5.42	6
		(14.63 - 45.44)	(787.15 - 1414.78)	(4.86 - 10.47)	(74.84 - 86.50)	
		18.91	1108.44	6.73	76.60	
	Nahm-wah	14.40 ± 10.59	618.66 ± 66.44	17.08 ± 6.22	76.55 ± 7.96	6
		(4.40 - 34.19)	(554.55 - 732.88)	(9.26 - 25.26)	(67.52 - 88.91)	
		12.39	603.87	16.11	76.99	

Table 12 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Macro-mineral contents (mg/100g dry wt.)				N
		Sodium	Potassium	Calcium	Magnesium	
Chinese pear	Hawm	31.92 ± 22.60	371.62 ± 180.65	39.76 ± 6.55	48.82 ± 3.53	6
		(0.00 - 64.14)	(98.12 - 382.46)	(32.49 - 48.19)	(45.38 - 53.95)	
		37.28	278.35	37.53	48.39	
	Namphung	27.87 ± 24.63	277.89 ± 103.93	13.11 ± 2.66	43.27 ± 7.60	6
		(1.07 - 69.90)	(212.21 - 605.18)	(10.61 - 16.93)	(36.62 - 56.82)	
		23.93	292.19	12.28	40.62	
Dragon fruit	Vietnam	26.42 ± 13.00	1797.56 ± 540.25	18.02 ± 2.92	150.45 ± 7.72	6
		(9.30 - 39.46)	(1175.22-2411.76)	(13.89 - 20.93)	(139.72 - 159.52)	
		29.13	1776.65	19.13	151.41	
Durain	Chanee	12.66 ± 6.64	1222.04 ± 567.11	12.63 ± 2.40	49.29 ± 7.00	6
		(6.24 - 22.57)	(500.51 - 2250.11)	(9.85 - 15.97)	(37.42 - 59.45)	
		10.65	1151.43	12.25	49.76	
	Mawntong	6.99 ± 2.47	1002.86 ± 137.56	13.85 ± 5.02	68.38 ± 20.23	6
		(3.75 - 10.14)	(757.88 -1163.43)	(9.02 - 20.89)	(30.83 - 88.66)	
		7.32	1028.22	12.82	71.92	

Table 12 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Macro-mineral contents (mg/100g dry wt.)				N
		Sodium	Potassium	Calcium	Magnesium	
Grape	Green	36.62 ± 29.60	714.47 ± 178.41	34.39 ± 7.59	30.89 ± 9.87	6
		(7.97 - 78.85)	(490.14 - 926.42)	(22.56 - 43.97)	(20.86 - 48.60)	
		28.87	776.62	35.93	29.12	
Guava	Pan-seetong	45.91 ± 12.00	1672.51 ± 684.23	25.44 ± 6.70	45.91 ± 3.06	6
		(22.82 - 57.06)	(829.42 - 2517.54)	(18.11 - 37.11)	(42.29 - 50.35)	
		49.87	1793.06	23.78	45.56	
Jack fruit		17.88 ± 12.03	798.34 ± 150.95	40.09 ± 6.91	72.93 ± 17.99	6
		(1.72 - 34.85)	(643.64 - 1010.91)	(28.63 - 47.26)	(51.93 - 102.93)	
		19.26	781.85	41.90	67.07	
Longan	Kalokbew	54.33 ± 21.85	521.22 ± 208.99	33.63 ± 3.79	41.69 ± 2.65	6
		(17.75 - 80.40)	(153.77 - 685.76)	(28.26 - 39.21)	(37.62 - 44.91)	
		58.52	614.05	32.96	42.09	
Longkong		14.70 ± 8.79	988.02 ± 360.63	40.70 ± 4.51	63.26 ± 4.88	6
		(7.46 - 30.45)	(292.13 - 1250.59)	(35.84 - 47.68)	(58.65 - 70.39)	
		12.22	1104.18	39.83	62.44	

Table 12 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Macromineral contents (mg/100g dry wt.)				N
		Sodium	Potassium	Calcium	Magnesium	
Lychee	Hohnghooway*	18.41 ± 14.44	702.51 ± 391.57	12.24 ± 3.09	55.46 ± 6.50	5
		(6.95 - 40.49)	(345.28 - 174.00)	(9.31 - 17.49)	(49.20 - 66.42)	
		12.19	589.90	11.39	53.75	
	Jackkrapat	14.64 ± 9.88	944.60 ± 563.40	12.87 ± 3.11	52.40 ± 9.33	6
		(1.44 - 28.18)	(236.85 - 1673.00)	(7.03 - 16.00)	(44.41 - 66.98)	
		13.98	1046.42	13.49	49.18	
Mango	Kheosawoei	2.83 ± 2.01	434.64 ± 60.24	25.30 ± 5.27	41.76 ± 7.17	6
	(unripe)	(0.00 - 5.17)	(374.89 - 545.93)	(19.32 - 33.88)	(32.76 - 50.59)	
		3.26	423.12	25.94	39.51	
	Nahmdawgmai	13.25 ± 15.38	407.73 ± 114.04	22.66 ± 6.42	44.52 ± 9.27	6
	(ripe)	(1.05 - 43.40)	(220.06 - 552.99)	(15.24 - 34.08)	(36.69 - 61.49)	
		8.67	411.74	21.85	41.34	
	Rad (unripe)	19.78 ± 12.10	596.07 ± 209.98	45.85 ± 9.51	42.25 ± 12.50	6
		(1.59 - 30.42)	(294.54 - 928.94)	(30.71 - 55.79)	(25.36 - 58.11)	
		24.39	578.17	48.94	41.48	

Table 12 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Macromineral contents (mg/100g dry wt.)				N
		Sodium	Potassium	Calcium	Magnesium	
Mangosteen		10.10 ± 4.71	159.26 ± 26.76	36.98 ± 9.06	60.90 ± 12.79	6
		(1.16 - 13.43)	(127.07 - 200.17)	(29.43 - 53.06)	(45.28 -75.27)	
		11.96	153.95	33.37	63.43	
Orange	Clementine	15.84 ± 11.52	676.49 ± 280.04	138.91 ± 35.19	69.27 ± 7.71	6
		(2.76 - 33.71)	(296.97 - 1012.71)	(117.10 - 208.09)	(59.20 - 79.09)	
		13.33	716.02	123.57	70.52	
	Sai-nuhm-phung	38.08 ± 19.06	1622.42 ± 184.98	102.00 ± 21.44	50.24 ± 6.65	6
		(6.31 - 62.30)	(1360.81-1932.88)	(64.14 - 121.33)	(41.46 - 62.08)	
		38.84	1605.46	107.02	49.61	
Papaya	Khak-dahm	27.75 ± 13.41	1933.50 ± 814.64	78.41 ± 4.69	69.37 ± 22.79	6
		(6.97 - 41.08)	(1329.06-3549.41)	(73.49 - 86.63)	(29.59 - 92.67)	
		30.79	1755.72	77.92	71.59	
Pineapple	Sri-ra-cha	24.63 ± 17.29	403.78 ± 207.54	67.11 ± 18.41	64.02 ± 23.81	6
		(5.36 - 56.62)	(55.89 - 678.91)	(36.12 - 88.57)	(30.56 - 98.16	
		23.15	403.32	70.31	65.42	

Table 12 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Macro-mineral contents (mg/100g dry wt.)				N
		Sodium	Potassium	Calcium	Magnesium	
Pomelo	Khao-nahm-peung	64.33 ± 17.18	673.71 ± 177.91	65.41 ± 28.80	40.48 ± 3.80	6
		(47.15 - 91.98)	(424.30 - 899.25)	(36.96 - 114.10)	(35.09 - 45.86)	
		62.79	676.31	61.97	40.22	
	Tongdee	69.80 ± 32.79	812.52 ± 107.21	83.78 ± 14.62	53.55 ± 3.76	6
		(20.53 - 115.49)	(639.78 - 918.47)	(67.83 - 106.63)	(48.39 - 59.31)	
		72.33	826.24	83.90	53.49	
Rambutan	Rong-rean	16.47 ± 9.73	403.70 ± 110.06	42.35 ± 1.81	51.35 ± 5.25	6
		(2.71 - 28.02)	(282.87 - 551.00)	(39.99 - 44.94)	(46.66 - 59.83)	
		18.07	393.32	42.08	50.15	
Rose apple	Toon-klow	46.79 ± 36.37	679.51 ± 626.82	22.28 ± 4.16	68.40 ± 6.03	6
		(19.81 - 117.63)	(277.06- 1823.88)	(18.91 - 27.75)	(61.03 - 75.29)	
		37.26	343.56	20.51	67.77	
	Tub- tim-jun	52.62 ± 18.62	959.60 ± 605.40	10.60 ± 1.57	59.75 ± 4.09	6
		(37.01 - 89.31)	(481.19- 1921.70)	(8.78 - 12.67)	(53.57 - 64.97)	
		47.59	681.16	10.04	59.76	

Table 12 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Macro-mineral contents (mg/100g dry wt.)				N
		Sodium	Potassium	Calcium	Magnesium	
Salacca		28.54 ± 13.27 (15.73 - 43.67) 25.93	575.60 ± 71.40 (492.56 - 693.87) 585.08	16.93 ± 11.65 (7.89 - 40.25) 13.39	41.95 ± 8.70 (33.32 - 57.74) 41.08	6
Sapodilla		66.69 ± 30.12 (40.20 - 115.87) 55.64	523.46 ± 74.62 (416.72 - 614.22) 526.91	60.24 ± 13.16 (45.76 - 82.95) 58.55	39.24 ± 3.13 (34.69 - 43.76) 39.21	6
Star fruit		27.31 ± 24.30 (0.00 - 58.62) 30.88	686.38 ± 166.45 (518.60 - 872.76) 677.10	14.45 ± 3.66 (10.90 - 18.89) 13.66	63.78 ± 9.79 (50.10 - 78.03) 64.91	6
Strawberry		31.87 ± 24.84 (7.46 - 73.02) 24.26	1262.34 ± 137.50 (1107.79-1450.93) 1263.30	112.37 ± 10.94 (98.05 - 130.96) 110.59	98.60 ± 21.56 (55.39 - 114.22) 105.09	6
Sugar apple	Nahng	2.99 ± 2.62 (0.00 - 6.13) 3.43	824.77 ± 314.36 (518.76 - 1414.52) 788.31	59.22 ± 7.70 (48.17 - 66.90) 62.05	81.19 ± 12.73 (65.78 - 102.48) 79.94	6

Table 12 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Macro-mineral contents (mg/100g dry wt.)				N
		Sodium	Potassium	Calcium	Magnesium	
Watermelon	Jin-trarah variety (red color)	45.27 ± 38.18 (9.59 - 113.52) 30.13	1072.31 ± 518.99 (472.16 - 1704.83) 1045.79	59.92 ± 48.45 (23.81 - 156.40) 46.20	75.78 ± 14.82 (58.55 - 95.97) 73.90	6
	Jin-trarah variety (yellow color)	36.44 ± 18.25 (13.85 - 58.52) 39.48	1306.69 ± 620.70 (679.68 - 2183.61) 1245.78	97.02 ± 19.69 (65.95 - 112.58) 105.91	88.84 ± 15.69 (71.55 - 107.02) 88.60	6

[1]Data were reported as a mean ± SD of duplicate analysis, range (min-max) and medium (n=6 sample/each kind of fruit)

With exception * n=5, **n=2

Table 12 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fruits in syrup)	Macro-mineral contents (mg/100g dry wt.)				N
	sodium	Potassium	Calcium	Magnesium	
Fruit cocktail or fruit salad **	17.74 ± 16.35 (6.18 - 29.30) 17.74	376.63 ± 37.97 (349.78 - 403.48) 376.63	48.10 ± 10.42 (40.73 - 55.47) 48.10	33.36 ± 14.82 (22.89 - 43.84) 33.36	2
Longan	9.99 ± 9.13 (0.00 - 22.21) 10.33	260.07 ± 80.86 (175.09 - 404.84) 255.95	105.41 ± 21.93 (78.45 - 139.76) 103.74	14.71 ± 1.68 (12.98 - 17.66) 14.53	6
Lychee	39.17 ± 72.86 (0.00 - 186.77) 11.92	334.77 ± 73.39 (242.58 - 432.16) 344.46	37.61 ± 15.49 (20.24 - 65.12) 33.44	20.53 ± 4.78 (10.87 - 23.19) 22.35	6
Rambutan	33.61 ± 53.52 (0.00 - 140.94) 19.37	136.88 ± 89.50 (62.20 - 288.46) 107.27	97.46 ± 22.27 (61.95 - 121.67) 102.93	19.55 ± 2.55 (15.81 - 23.36) 19.75	6

[1]Data were reported as a mean ± SD of duplicate analysis, range (min-max) and medium (n=6 sample/each kind of fruit)

With exception * n=5, **n=2

Table 13 Macro-mineral contents in fresh fruits and fruits in syrup[1]

English name (Fresh fruits)	Variety	Macro-mineral contents (mg/100 g edible portion)				N
		Sodium	Potassium	Calcium	Magnesium	
Apple	Fuji	1.78 ± 2.10 (0.00 - 5.08) 0.83	29.25 ± 7.48 (18.11 - 36.33) 32.99	3.79 ± 0.52 (3.23 - 4.58) 3.66	3.55 ± 0.65 (3.01 - 4.79) 3.37	6
	Granny Smith	2.43 ± 1.96 (0.39 - 5.76) 2.21	29.45 ± 22.00 (10.54 - 70.22) 22.54	4.79 ± 0.73 (3.76 - 5.54) 4.94	4.12 ± 0.30 (3.57 - 4.43) 4.14	6
Banana (ripe)	Hawm	4.14 ± 3.33 (1.05 - 8.55) 2.79	346.98 ± 58.07 (255.63 - 413.01) 356.62	2.69 ± 0.82 (1.90 - 4.19) 2.41	21.45 ± 1.02 (19.99 - 23.08) 21.42	6
	Kai	6.70 ± 3.28 (4.15 - 12.89) 5.37	309.75 ± 75.07 (223.30 - 401.35) 314.45	2.03 ± 0.53 (1.38 - 2.97) 1.91	22.53 ± 1.54 (21.23 - 24.54) 21.73	6
	Nahm-wah	4.74 ± 3.49 (1.45 - 11.26) 4.08	203.78 ± 21.89 (182.66 - 241.40) 198.91	5.63 ± 2.05 (3.05 - 8.32) 5.31	25.21 ± 2.62 (22.24 - 29.29) 25.36	6

Table 13 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Macro-mineral contents (mg/100 g edible portion)				N
		Sodium	Potassium	Calcium	Magnesium	
Chinese pear	Hawm	4.66 ± 3.30	40.54 ± 15.16	5.80 ± 0.96	7.12 ± 0.51	6
		(0.00 - 9.36)	(14.31 - 55.80)	(4.74 - 7.03)	(6.62 - 7.87)	
		5.44	40.61	5.48	7.06	
	Namphung	3.84 ± 3.39	51.15 ± 24.86	1.81 ± 0.37	5.96 ± 1.05	6
		(0.15 - 9.62)	(29.21 - 83.29)	(1.46 - 2.33)	(5.04 - 7.82)	
		3.29	40.22	1.69	5.59	
Dragon fruit	Vietnam	3.98 ± 1.96	270.56 ± 81.32	2.71 ± 0.44	22.65 ± 1.16	6
		(1.40 - 5.94)	(176.89 - 363.01)	(2.09 - 3.15)	(21.03 - 24.01)	
		4.39	267.42	2.88	22.79	
Durain	Chanee	4.20 ± 2.20	405.60 ± 188.22	4.19 ± 0.80	16.36 ± 2.32	6
		(2.07 - 7.49)	(166.12 - 746.81)	(3.27 - 5.30)	(12.42 - 19.73)	
		3.54	382.16	4.07	16.52	
	Mawntong	2.03 ± 0.72	291.82 ± 40.03	4.03 ± 1.46	19.90 ± 5.89	6
		(1.09 - 2.95)	(220.53 - 338.54)	(2.63 - 6.08)	(8.97 - 25.80)	
		2.13	299.20	3.73	20.93	

Table 13 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Macro-mineral contents (mg/100 g edible portion)				N
		Sodium	Potassium	Calcium	Magnesium	
Grape	Green	6.39 ± 5.16 (1.39 - 13.76) 5.04	124.68 ± 31.13 (85.53 - 161.66) 135.52	6.00 ± 1.33 (3.94 - 7.67) 6.27	5.39 ± 1.72 (3.64 - 8.48) 5.08	6
Guava	Pan-seetong	5.75 ± 1.50 (2.86 - 7.15) 6.25	209.59 ± 85.75 (103.94 - 315.49) 224.70	3.19 ± 0.84 (2.27 - 4.65) 2.98	5.75 ± 0.38 (5.30 - 6.31) 5.71	6
Jackfruit		4.63 ± 3.12 (0.45 - 9.03) 4.99	206.93 ± 39.13 (166.83 - 262.03) 202.65	10.39 ± 1.79 (7.42 - 12.25) 10.86	18.90 ± 4.66 (13.46 - 26.68) 17.39	6
Longan	Kalokbew	10.96 ± 4.41 (3.58 - 16.22) 11.81	105.15 ± 42.16 (31.02 - 138.34) 123.88	6.78 ± 0.76 (5.70 - 7.91) 6.65	8.41 ± 0.54 (7.59 - 9.06) 8.49	6
Longkong		2.85 ± 1.71 (1.45 - 5.91) 2.37	191.87 ± 70.03 (56.73 - 242.86) 214.43	7.90 ± 0.88 (6.96 - 9.26) 7.74	12.29 ± 0.95 (11.39 - 13.67) 12.13	6

Table 13 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Macro-mineral contents (mg/100 g edible portion)				N
		Sodium	Potassium	Calcium	Magnesium	
Lychee	Hohnghooway*	3.44 ± 2.70	131.36 ± 73.22	2.29 ± 0.58	10.37 ± 1.22	5
		(1.30 - 7.57)	(64.56 - 256.91)	(1.74 – 3.27)	(9.20 - 12.42)	
		2.28	110.30	2.13	10.05	
	Jackkrapat	2.56 ± 1.73	165.27 ± 98.58	2.25 ± 0.54	9.17 ± 1.63	6
		(0.25 - 4.93)	(41.44 - 292.72)	(1.23 - 2.80)	(7.77 - 11.72)	
		2.45	183.09	2.36	8.61	
Mango	Kheosawoei	0.59 ± 0.41	89.88 ± 12.46	5.23 ± 1.09	8.64 ± 1.48	6
	(unripe)	(0.00 - 1.07)	(77.52 - 112.89)	(3.99 - 7.01)	(6.77 - 10.46)	
		0.68	87.50	5.36	8.17	
	Nahmdawgmai	2.64 ± 3.07	81.36 ± 22.75	4.52 ± 1.28	8.88 ± 1.85	6
	(ripe)	(0.21 - 8.66)	(43.91 - 110.34)	(3.04 - 6.80)	(7.32 - 12.27)	
		1.73	82.16	4.36	8.25	
	Rad (unripe)	3.48 ± 2.13	104.83 ± 36.93	8.06 ± 1.67	7.43 ± 2.20	6
		(0.28 - 5.35)	(51.80 - 163.37)	(5.40 - 9.81)	(4.46 - 10.22)	
		4.29	101.68	8.61	7.30	

Table 13 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Macro-mineral contents (mg/100g edible portion)				N
		Sodium	Potassium	Calcium	Magnesium	
Mangosteen		2.00 ± 0.93	31.55 ± 5.30	7.33 ± 1.79	12.06 ± 2.53	6
		(0.23 - 2.66)	(25.17 - 39.65)	(5.83 - 10.51)	(8.97 - 14.91)	
		2.37	30.50	6.61	12.57	
Orange	Clementine	1.96 ± 1.42	83.65 ± 34.63	17.18 ± 4.35	8.57 ± 0.95	6
		(0.34 - 4.17)	(36.72 - 125.22)	(14.48 - 25.73)	(7.32 - 9.78)	
		1.65	88.54	15.28	8.72	
	Sai-nuhm-phung	5.37 ± 2.69	228.92 ± 26.10	14.39 ± 3.02	7.09 ± 0.94	6
		(0.89 - 8.79)	(192.01 - 272.73)	(9.05 - 17.12)	(5.85 - 8.76)	
		5.48	226.53	15.10	7.00	
Papaya	Khak-dahm	2.85 ± 1.38	198.64 ± 83.69	8.06 ± 0.48	7.13 ± 2.34	6
		(0.72 - 4.22)	(136.54 - 364.64)	(7.55 - 8.90)	(3.04 - 9.52)	
		3.16	180.37	8.01	7.36	
Pineapple	Sri-ra-cha	3.72 ± 2.61	61.05 ± 31.38	10.15 ± 2.78	9.68 ± 3.60	6
		(0.81 - 8.56)	(8.45 - 102.64)	(5.46 - 13.39)	(4.62 - 14.84)	
		3.50	60.98	10.63	9.89	

Table 13 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Macro-mineral contents (mg/100g edible portion)				N
		Sodium	Potassium	Calcium	Magnesium	
Pomelo	Khao-nahm-peung	7.59 ± 2.03	79.48 ± 20.99	7.72 ± 3.40	4.78 ± 0.45	6
		(5.56 - 10.85)	(50.05 - 106.08)	(4.36 - 13.46)	(4.14 - 5.41)	
		7.41	79.78	7.31	4.75	
	Tongdee	7.86 ± 3.69	91.52 ± 12.07	9.44 ± 1.65	6.03 ± 0.42	6
		(2.31 - 13.01)	(72.06 - 103.45)	(7.64 - 12.01)	(5.45 - 6.68)	
		8.15	93.06	9.45	6.03	
Rambutan	Rong-rean	3.16 ± 1.87	77.52 ± 21.14	8.13 ± 0.35	9.86 ± 1.01	6
		(0.52 - 5.38)	(54.32 - 105.81)	(7.68 - 8.63)	(8.96 - 11.49)	
		3.47	75.53	8.08	9.63	
Rose apple	Toon-klow	4.23 ±3.29	61.46 ± 56.70	2.02 ± 0.38	6.19 ± 0.55	6
		(1.79 - 10.64)	(25.06 - 164.97)	(1.71 - 2.51)	(5.52 - 6.81)	
		3.37	31.08	1.86	6.13	
	Tub- tim-jun	5.82 ± 2.06	106.05 ± 66.91	1.17 ± 0.17	6.60 ± 0.45	6
		(4.09 - 9.87)	(53.18 - 212.38)	(0.97 - 1.40)	(5.92 - 7.18)	
		5.26	75.28	1.11	6.61	

Table 13 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Macro-mineral contents (mg/100g edible portion)				N
		Sodium	Potassium	Calcium	Magnesium	
Salacca		5.68 ± 2.64	114.55 ± 14.21	3.37 ± 2.32	8.35 ± 1.73	6
		(3.13 - 8.69)	(98.02 - 138.08)	(1.57 - 8.01)	(6.63 - 11.49)	
		5.16	116.43	2.67	8.18	
Sapodilla		16.32 ± 7.37	128.11 ± 18.26	14.74 ± 3.22	9.60 ± 0.77	6
		(9.84 - 28.36)	(101.99 - 150.32)	(11.20 - 20.30)	(8.49 - 10.71)	
		13.62	128.95	14.33	9.60	
Star fruit		2.95 ± 2.62	74.12 ± 17.97	1.56 ± 0.39	6.89 ± 1.06	6
		(0.00 - 6.33)	(56.00 - 94.24)	(1.18 - 2.04)	(5.41 - 8.43)	
		3.34	73.12	1.48	7.01	
Strawberry		3.33 ± 2.60	131.96 ± 14.37	11.75 ± 1.14	10.31 ± 2.25	6
		(0.78 - 7.63)	(115.80 - 151.67)	(10.25 - 13.69)	(5.79 - 11.94)	
		2.54	132.06	11.56	10.99	
Sugar apple	Nahng	0.78 ± 0.68	213.52 ± 81.38	15.33 ± 1.99	21.02 ± 3.30	6
		(0.00 - 1.59)	(134.30 - 366.20)	(12.47 - 17.32)	(17.03 - 26.53)	
		0.89	204.08	16.07	20.70	

Table 13 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Macro-mineral contents (mg/100g edible portion)				N
		Sodium	Potassium	Calcium	Magnesium	
Watermelon	Jin-trarah variety (red color)	5.06 ± 4.27 (1.07 - 12.68) 3.37	119.78 ± 57.97 (52.74 - 190.43) 116.82	6.69 ± 5.41 (2.66 - 17.47) 5.16	8.47 ± 1.65 (6.54 - 10.72) 8.26	6
	Jin-trarah variety (yellow color)	3.11 ±1.56 (1.18 - 4.99) 3.36	111.35 ± 52.89 (57.92 - 186.08) 106.16	8.27 ± 1.68 (5.62 - 9.59) 9.03	7.57 ± 1.34 (6.10 - 9.12) 7.55	6

[1]Data were reported as a mean ± SD of duplicate analysis, range (min-max) and medium (n=6 sample/each kind of fruit)

With exception * n=5, **n=2

Table 13 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fruits in syrup)	Macro-mineral contents (mg/100g edible portion.)				N
	sodium	Potassium	Calcium	Magnesium	
Fruit cocktail or fruit salad **	3.77 ± 3.47 (1.31 - 6.22) 3.77	79.98 ± 8.06 (74.28 - 85.68) 79.98	10.22 ± 2.21 (8.65 - 11.78) 10.22	7.09 ± 3.15 (4.86 - 9.31) 7.09	2
Longan	2.09 ± 1.91 (0.00 - 4.65) 2.16	54.50 ± 16.95 (36.69 - 84.84) 53.64	22.09 ± 4.60 (16.44 - 29.29) 21.74	3.08 ± 0.35 (2.72 - 3.70) 3.05	6
Lychee	8.90 ± 16.56 (0.00 - 42.45) 2.71	76.09 ± 16.68 (55.13 - 98.22) 78.29	8.55 ± 3.52 (4.60 - 14.80) 7.60	4.67 ± 1.09 (2.47 - 5.27) 5.08	6
Rambutan	6.95 ± 11.07 (0.00 - 29.14) 4.01	28.30 ± 18.51 (12.86 - 59.65) 22.18	20.15 ± 4.61 (12.81 - 25.16) 21.29	4.04 ± 0.53 (3.27 - 4.83) 4.09	6

[1]Data were reported as a mean ± SD of duplicate analysis, range (min-max) and medium (n=6 sample/each kind of fruit)

With exception * n=5, **n=2

Table 14 Macro-mineral contents in fresh fruits and fruits in syrup[1]

English name (Fresh fruits)	Variety	One portion (g)[2]	Macro-mineral contents (mg/portion of weight)				N
			sodium	Potassium	Calcium	Magnesium	
Apple	Fuji	102	2	30	4	4	6
	Granny Smith	102	2	29	5	4	6
Banana (ripe)	Hawm	53	2	184	1	11	6
	Kai	48	3	149	1	11	6
	Nahm-wah	53	3	108	3	13	6
Chinese pear	Hawm	136	6	55	8	10	6
	Namphung	135	5	69	2	8	6
Dragon fruit	Vietnam	120	5	325	3	27	6
Durain	Chanee	58	2	235	2	9	6
	Mawntong	50	1	145	2	10	6
Grape	green	93	6	116	6	5	6
Guava	Pan-seetong	123	7	258	4	7	6
Jack fruit		61	3	126	6	12	6

Table 14 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	One portion (g)[2]	Macro-mineral contents (mg/portion of weight)				N
			sodium	Potassium	Calcium	Magnesium	
Longan	Kalokbew	86	9	90	6	7	6
Longkong		94	3	180	7	12	6
Lychee	Hohnghooway*	98	3	129	2	10	5
	Jackkrapat	78	2	129	2	7	6
Mango	Kheosawoei(unripe)	75	0	68	4	7	6
	Nahmdawgmai(ripe)	79	2	64	4	7	6
	Rad (unripe)	76	3	80	6	6	6
Mangosteen		77	2	24	6	9	6
Orange	Clementine	101	2	84	17	9	6
	Sai-nuhm-phung	122	7	279	18	9	6
Papaya	Khak-dahm	130	4	258	10	9	6
Pineapple	Sri-ra-cha	101	4	62	10	10	6

Table 14 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	One portion (g)[2]	Macro-mineral contents (mg/portion of weight.)				N
			sodium	Potassium	Calcium	Magnesium	
Pomelo	Khao-nahm-peung	92	7	73	7	4	6
	Tongdee	125	10	114	12	8	6
Rambutan	Rong-rean	75	2	58	6	7	6
Rose apple	Toon-klow	205	9	126	4	13	6
	Tub- tim-jun	152	9	161	2	10	6
Salacca		78	4	89	3	7	6
Sapodilla		69	11	88	10	7	6
Star fruit		159	5	118	2	11	6
Strawberry		180	6	238	21	19	6
Sugar apple	Nahng	57	0	122	9	12	6
Watermelon	Jin-trarah variety (red color)	170	9	204	11	14	6
	Jin-trarah variety (yellow color)	188	6	204	11	14	6

Table 14 Macro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fruits in syrup)	One portion (g)[2]	Macro-mineral contents (mg/portion of weight.)				N
		sodium	Potassium	Calcium	Magnesium	
Fruit cocktail or fruit salad **	91	3	73	9	6	2
Longan	71	1	39	16	2	6
Lychee	70	6	53	6	3	6
Rambutan	63	4	18	13	3	6

[1]Data were reported as a mean of duplicate analysis (n=6 sample/each kind of fruit) With exception * n=5, **n=2

[2] One portion of fresh and canned fruits was calculated by based on 15 gram of carbohydrate that recommended from the food exchange list (68)

5.2.2 Potassium content of fresh fruits and fruits in syrup

Wide variation of potassium content in all selected fruits was observed as showed in table 12 and the values were reported to mg/100 g dry wt. The range of potassium contents was between 136.88 to 1933.50 mg/100 g dry wt or 28.30 to 405.60 mg/100g edible portion. Ripe papaya; Khak-dham variety was found to be a highest source of potassium content (1933.50 mg/100 g dry wt or198.64 mg/100g edible portion). The classified levels of potassium are based on the Quartile deviation, high level (more than 999.15 mg/100 g dry wt), medium level (403.72 to 999.15 mg/100 g dry wt) and low level (less than 403.72 mg/100 g dry wt). The high potassium content (1002.86 to 1797.56 mg/100 g dry wt or 270.56 to 291.82 mg/100g edible portion) was found in durian (Mawntong variety), watermelon (Jin-trarah variety, red), ripe banana (Kai variety), durian (Chanee variety), strawberry, watermelon (Jin-trarah, yellow), ripe banana (Hawm variety), orange (Sai-nuhm-phung variety), guava (Pan-seetong variety) and dragon fruit (Vietnam variety). The moderate amounts of potassium contents were found in pineapple (Sri-ra-cha variety) , mango both in Nahmdawgmai (ripe), Kheosawoei (unripe) varieties, longan (Kalokbew variety), sapodilla, salacca, unripe mango (Rad variety), ripe banana (Nahm-wah variety), pomelo (Khao-nahm-peung variety), orange (Clementine variety), rose apple (Toon-klow variety), star fruit, lychee (Hohnghooway variety), grape (Green variety), jackfruit, pomelo (Tongdee variety), sugar apple (Nahng variety), lychee (Jackkrapat variety), rose apple (Tub-tim-jun variety) and longkong which ranging from 403.78-988.02 mg/100 g dry wt or 61.05 to 191.87 mg/100g edible portion. The low amounts of potassium were found in rambutan in syrup, mangosteen, apple (Fuji, Granny Smith varieties), longan in syrup, chinese pear (Hawm variety), lychee in syrup, chinese pear (Namphung variety), fruit salad and rambutan (Rong-rean variety) (136.88- 403.70 mg/100 g dry wt or 28.30 to 61.05 mg/100g edible portion).

Base on one portion of food exchange list (68) that fruit contained low, medium and high potassium contents were less than 4 mEq (less than 156.4 mg) for low, 4-7 mEq (156.4 to 273.7 mg) medium and 7 mEq for high (more than 273.7 mg), respectively. According to the food exchange list, it was found that orange (Sai-nuhm-phung) and dragon fruit (Vietnam variety) contained high potassium per one portion which ranged from 279 to 325 mg/portion. It was noted that almost of all

selected fresh fruits in this study are good sources of potassium as showed in table 14.

5.2.3 Calcium content of selected Thai fruits (mg/100 g dry wt)

The calcium content of selected Thai fruits ranged from 7.17 to 138.91 mg/100 g dry wt or 1.17 to 22.09 mg/100g edible portion was showed in table 12 and 13. Comparison among the amount of calcium in all samples showed that orange (Clementine) was a highest source of calcium content (138.91 mg/100 g dry wt or 17.18 mg/100g edible portion). The levels of calcium were categorized according to the Quartile deviation into three levels. The results showed that the high level was more than 60.16 mg/100 g dry wt, medium level ranged between 16.97 to 60.16 mg/100 g dry wt and low level was less than 16.97 mg/100 g dry wt. High calcium contents were found in sapodilla, pomelo (Khao-nahm-peung variety), pineapple (Sri-ra-cha variety), ripe papaya (Kaegdahm variety), pomelo (Tongdee variety), watermelon (Jin-trarah variety, yellow), rambutan in syrup, orange (Sai-nuhm-phung variety), longan in syrup and strawberry which ranged from 60.24 to 112.37 mg/100 g dry wt The moderate amount (17.08-59.92 mg/100 g dry wt) of calcium value was found in ripe banana (Nahm-wah variety), dragon fruit (Vietnam variety), rose apple (Toon-klow variety), mango [Nahmdawgmai (ripe) and Kheosawoei (unripe) varieties], guava (Pan-seetong variety), apple (Fuji variety), longan (Kalokbew variety), apple (Granny Smith variety), grape (Green variety), mangosteen, lychee in syrup, chinese pear (Hawm variety), jack fruit, longkong, rambutan (Rong-rean variety), unripe mango (Rad variety), fruit salad, sugar apple (Nahng variety) and watermelon (Jin-trarah variety, red). And the low amount of calcium was found in ripe banana (Kai variety), rose apple (Tub-timjun variety), ripe banana (Hawm variety), lychee (Hohnghooway variety), durian (Chanee variety), lychee (Jackkrapat variety), chinese pear (Namphung variety), durian (Mawntong variety), star fruit and salacca (7.17-16.93 mg/100 g dry wt, respectively).

Data of the calcium content per portion of fresh fruits and fruits in syrup were calculated by base on the weight of one portion were showed in Table 14. Calcium content ranged from 1 to 21 mg/portion. The highest amount of calcium content was found in strawberry (21 mg/portion)] and ripe banana (Hawm and Kai varieties) had the lowest amount of calcium content (1 mg/portion).

5.2.4 Magnesium content of fresh fruits and fruits in syrup

In fresh fruits and fruits in syrup, the magnesium content ranged from 14.71 to 150.45 mg/100 g dry wt as showed in table 12. Comparison among the magnesium content between various fresh fruits variety and fruits in syrup showed that dragon fruit (Vietnam variety) was the highest source of magnesium (150.45 mg/100 g dry wt and 22.65 mg/100g edible portion). When the Quartile deviation was used for setting the levels of magnesium content in selected fruits and fruit in syrup, the levels of magnesium content were divided into three levels. High level was set to more than 69.05 mg/100 g dry wt, medium level was between 41.71 to 69.05 mg/100 g dry wt and low level was less than 41.71 mg/100 g dry wt. High concentration of magnesium was found in orange (Clementine variety), ripe papaya (Kaegdahm variety), jack fruit, watermelon (Jin-trarah variety, red), ripe banana (Nahm-wah, Kai varieties), sugar apple (Nahng variety), ripe banana (Hawm variety), watermelon (Jin-trarah variety, yellow) and strawberry which ranged from 69.27-98.6 mg/100 g dry wt. The moderate amount (41.76 to 68.4 mg/100 g dry wt) of magnesium was found in unripe mango (Kheosawoei variety), salacca, unripe mango (Rad variety), chinese pear (Namphung variety), ripe mango (Nahmdawgmai variety), guava (Pan-seetong variety), chinese pear (Hawm variety), durian (Chanee variety), orange (Sai-nuhm-phung variety), rambutan (Rong-rean variety), lychee (Jackkrapat variety), pomelo (Tongdee variety), lychee (Hohnghooway variety), rose apple (Tub-tim-jun variety), mangosteen, longkong, star fruit, pineapple (Sri-ra-cha variety), durian (Mawntong variety) and rose apple (Toon-klow variety). Low concentration of magnesium was less than 41.71 mg/100 g dry wt. and found in longan in syrup (14.71 mg/100 g dry wt), rambutan in syrup (19.55 mg/100 g dry wt), lychee in syrup (20.53 mg/100 g dry wt), apple (Fuji variety, 23.83 mg/100 g dry wt), apple (Granny Smith variety, 29.47 mg/100 g dry wt), grape (Green variety, 30.89 mg/100 g dry wt), fruit salad (33.36 mg/100 g dry wt), sapodilla (39.24 mg/100 g dry wt), pomelo (Khao-nahm-peung variety, 40.48 mg/100 g dry wt), and longan (Kalokbew variety, 41.69 mg/100 g dry wt).

The amount of magnesium value of each kind of fresh fruits and fruits in syrup was calculated for one portion by following the food exchange lists that one portion of fruit is equal to 15 g of carbohydrate (68) and then Food Composition Table (69) was

used to calculate the weight of each fruit per one portion. Considering on the unit of milligrams per one portion, the range of magnesium content was between 2 to 27 mg/portion. Dragon fruit (Vietnam variety) had the highest content of magnesium content per one portion. In contrast, the lowest content of magnesium (2 mg/portion) was found in longan in syrup, see in Table 14.

5.3 Micro-minerals Content Analysis

The micro-mineral contents of fresh fruits and fruits in syrup are shown in Table 15 or 16 and Table 17 (per 100 g dry wt or per 100 g edible portion and per portion). The micro-mineral contents were varied among Iron (Fe), Copper (Cu) and Zinc (Zn) content in different varieties of fresh fruit or fruit in syrup. The data of micro-mineral was determined in term of milligram per 100 g edible portion and then they were converted to per 100 g dry wt and milligram per portion.

5.3.1 Iron content of fresh fruits and fruits in syrup

In all selected fruits, the wide variation of iron content was observed in this study which ranged from 0.54 to 3.01 mg/100 g dry wt in fresh fruits and 0.70 to 0.94 mg/100 g dry wt in canned fruits. The highest amount of iron was found in watermelon [Jin-trarah variety (yellow), 1.79 mg/100 g dry wt] and strawberry (3.01 mg/100 g dry wt). Base on the Quartile deviation, iron are divided into three levels. The high level of iron was more than 1.14 mg/100 g dry wt, medium level ranged from 0.80-1.14 mg/100 g dry wt, and low level was less than 0.80 mg/100 g dry wt. The high iron content was found in grape (Green variety), pineapple (Sri-ra-cha variety), guava (Pan-seetong variety), lychee (Hohnghooway variety), rose apple (Toon-klow variety), dragon fruit (Vietnam variety), ripe papaya (Khakdahm variety), chinese pear (Hawm variety), watermelon (Jin-trarah variety, red) and star fruit which ranged from 1.14 to 1.66 mg/100 g dry wt. The moderate amount of iron content (0.82 to 1.11 mg/100 g dry wt) was found in unripe mango (Kheosawoei variety), lychee (Jackkrapat varieties), fruit salad, orange (Sai-nuhm-phung, Clementine varieties), ripe banana (Kai variety), lychee in syrup, durian (Chanee variety), ripe banana (Hawm variety), longkong, rose apple (Tub-tim-jun variety), ripe banana (Nahm-wah variety), salacca, pomelo (Tongdee, Khao-nahm-peung varieties), jackfruit, longan (Kalokbew

variety) and apple (Granny Smith variety). While low level was found in chinese pear (Namphung variety), sapodilla, mangosteen, longan in syrup, durian (Mawntong variety), rambutan in syrup, mango (ripe Nahmdawgmai and unripe Rad varieties) rambutan (Rong-rean variety), sugar apple (Nahng variety) and apple (Fuji variety) (0.54-0.80 mg/100 g dry wt).

When the data were converted to milligram per one portion based on 15 g of carbohydrate that recommended by food exchange list (68), the amount of iron values ranged from 0.1 to 0.6 mg/one portion. The highest was found in strawberry (0.6 mg/one portion), while the lowest was found in apple (Fuji variety), banana (Hawm and Kai varieties), chinese pear (Namphung variety), durian (Mawntong variety), lychee (Jackkrapat variety), mango (Kheosawoei; unripe, Nahmdawgmai; ripe, Rad; unripe varieties), mangosteen, orange (Clementine variety), pomelo (Khao-nahm-phung variety), rambutan (Rong-rean variety), sapodilla, sugar apple (Nahng variety), longan in syrup and rambutan in syrup (0.1 mg/one portion).

5.3.2 Copper content in fresh fruit and fruit in syrup

The range of copper content of all samples was 0.18 to 1.59 mg/100 g dry wt (Table 15 and 16). The copper content ranged from 0.18 to 1.59 mg/100 g dry wt in fresh fruits and 0.26 to 0.43 mg/100 g dry wt in canned fruits. Lychee (Hohnghooway variety) and grape (Green variety) were the highest source of copper in fresh and canned fruits (1.04 and 1.59 mg/100 g dry wt, respectively). The data were divided into three levels by the Quartile deviation, high level (more than 0.60 mg/100 g dry wt), medium level (0.38 - 0.60 mg/100 g dry wt) and low level (less than 0.38 mg/100 g dry wt). High level of copper content (0.60-0.89 mg/100 g dry wt) was found in unripe mango (Kheosawoei variety), lychee (Jackkrapat variety), watermelon (Jin-trarah variety, yellow), durian (Chanee variety), longan (Kalokbew variety), guava (Pan-seetong variety), durian (Mawntong variety), jackfruit, rambutan (Rong-rean variety) and unripe mango (Rad variety). Medium level of copper content was found in rose apple (Tub-tim-jun variety), ripe papaya (Khakdahm variety), rambutan in syrup, sugar apple (Nahng variety), lychee in syrup, ripe banana (Hawm variety), pomelo (Khao-nahm-peung variety), apple (Granny Smith variety), star fruit, pomelo (Tongdee variety), ripe banana (Kai variety), mangosteen, rose apple (Toon-klow

variety), chinese pear (Namphung variety), orange (Clementine variety), chinese pear (Hawm variety), watermelon (Jin-trarah variety, red), longkong and strawberry which ranged from 0.39 -0.59 mg/100 g dry wt. The low amount of copper was found in sapodilla, fruit salad, ripe banana (Nahm-wah variety), orange (Sai-nuhm-phung variety), pineapple (Sri-ra-cha variety), salacca, longan in syrup, dragon fruit (Vietnam variety), ripe mango (Nahmdawgmai variety) and apple (Fuji variety) ranging from 0.18-0.38 mg/100 g dry wt.

One portion of fresh and canned fruits was calculated by based on 15 gram of carbohydrate that recommended from the food exchange list (68). Copper content of edible portion of fresh fruits and fruits in syrup per one portion was shown in Table 17. Grape (green variety) was the highest source of copper (0.26 mg/portion) and the lowest sources of copper were banana (Nahm-wah variety), papaya (Khak-dahm variety), pineapple (Sriracha variety), pomelo (Khao-nahm-phung variety) and sapodilla (approximately 0.03 mg/portion).

5.3.3 Zinc content in fresh fruits and fruits in syrup

The values of zinc content in fresh and canned fruits were shown in Table 15 and 16. The values of zinc content ranged from 0.28 to 1.97 mg/100 g dry wt. The values of zinc content in fresh and canned fruits ranged from 0.29 to 1.97 and 0.28 to 0.52 mg/100 g dry wt, respectively. The highest sources of zinc in fresh fruits and fruits in syrup were found in longkong, dragon fruit (Vietnam variety), strawberry and star fruit (1.22 to 1.97 mg/100 g dry wt). According to the Quartile deviation, zinc contents were divided into three levels; high level (more than 0.66 mg/100 g dry wt), medium level (0.42 to 0.66 mg/100 g dry wt) and low level (less than 0.42 mg/100 g dry wt). High content of zinc was found in rambutan (Rong-rean variety), longan (Kalokbew variety), lychee (Jackkrapat variety), salacca, durian (Chanee variety), guava (Pan-seetong variety), lychee (Hohnghooway variety), watermelon (Jin-trarah variety, yellow) and ripe papaya (Khakdahm variety) ranging from 0.69-1.02 mg/100 g dry wt). Medium content of zinc was found in ripe banana (Nahm-wah variety), unripe mango (Kheosawoei variety), grape (Green vatiery), pomelo (Tongdee variety), pineapple (Sri-ra-cha variety), ripe banana (Hawm variety), mangosteen, chinese pear (Namphung variety), pomelo (Khao-nahm-peung variety), fruit salad, chinese pear

(Hawm variety), jackfruit, ripe banana (Kai variety), durian (Mawntong variety), rose apple (Toon-klow variety), watermelon (Jin-trarah variety, red) and sugar apple (Nahng variety) which ranged from 0.43-0.62 mg/100 g dry wt. And low content of zinc (0.28-0.42 mg/100 g dry wt) was found in rambutan in syrup, apple (Fuji and Granny Smith varieties) sapodilla, longan in syrup, orange (Sai-nuhm-phung variety), ripe mango (Nahmdawgmai variety), lychee in syrup, rose apple (Tub-tim-jun variety), unripe mango (Rad variety) and orange (Clementine).

Zinc contents of edible portion of fresh fruits and fruits in syrup per milligram per one portion were show in Table 17. The highest zinc content was found in star fruit and Strawberry (approximately 0.3 mg/portion), while the lowest zinc content was found in apple (Granny Smith variety) and rambutan in syrup with approximately 0 mg/portion.

The comparison among the macro-micro minerals between fruit in syrup and fresh fruit found that fruits in syrup had lower both in macro-micro elements than fresh fruit as compared in per 100 g dry wt however, both fresh fruits or fruits in syrup contained only small amount of micro-minerals.

Table 15 Micro-mineral contents in fresh fruits and fruits in syrup[1]

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g dry wt.)			N
		Iron	Zinc	Copper	
Apple	Fuji	0.80 ± 0.08 (0.74 – 0.94) 0.77	0.30 ± 0.11 (0.20 – 0.47) 0.27	0.38 ± 0.03 (0.34 – 0.40) 0.40	6
	Granny Smith	1.11 ± 0.15 (0.93 – 1.29) 1.15	0.29 ± 0.10 (0.14 – 0.43) 0.29	0.44 ± 0.10 (0.29 – 0.57) 0.43	6
Banana (ripe)	Hawm	0.99 ± 0.10 (0.89 - 1.14) 0.96	0.47 ± 0.07 (0.37 – 0.54) 0.49	0.44 ± 0.07 (0.33 – 0.53) 0.45	6
	Kai	0.91 ± 0.07 (0.78 - 0.96) 0.93	0.59 ± 0.13 (0.37 – 0.74) 0.60	0.48 ± 0.12 (0.39 – 0.71) 0.43	6
	Nahm-wah	1.01 ± 0.11 (0.88 – 1.15) 0.99	0.43 ± 0.10 (0.34 – 0.61) 0.41	0.31 ± 0.08 (0.23 – 0.46) 0.31	6

Table 15 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g dry wt.)			N
		Iron	Zinc	Copper	
Chinese pear	Hawm	1.58 ± 0.06 (1.51 – 1.65) 1.58	0.58 ± 0.28 (0.27 – 0.96) 0.48	0.56 ± 0.09 (0.48 – 0.69) 0.55	6
	Namphung	0.54 ± 0.06 (0.51 – 0.65) 0.51	0.47 ± 0.10 (0.36 – 0.65) 0.44	0.53 ± 0.08 (0.44 – 0.65) 0.51	6
Dragon fruit	Vietnam	1.40 ± 0.07 (1.33 – 1.53) 1.40	1.32 ± 0.07 (1.26 – 1.40) 1.30	0.38 ± 0.08 (0.33 – 0.53) 0.33	6
Durain	Chanee	0.96 ± 0.20 (0.69 – 1.21) 0.98	0.80 ± 0.25 (0.48 – 1.21) 0.77	0.66 ± 0.09 (0.54 – 0.78) 0.66	6
	Mawntong	0.73 ± 0.24 (0.38 – 1.13) 0.72	0.60 ± 0.23 (0.27 – 0.92) 0.58	0.72 ± 0.29 (0.41 – 1.10) 0.74	6

Table 15 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g dry wt.)			N
		Iron	Zinc	Copper	
Grape	Green	1.14 ± 0.52 (0.77 – 2.17) 1.03	0.44 ± 0.16 (0.34 – 0.77) 0.38	1.59 ± 1.10 (0.29 – 3.21) 1.67	6
Guava	Pan-seetong	1.20 ± 0.10 (1.12 – 1.36) 1.16	0.81 ± 0.31 (0.64 – 1.44) 0.72	0.70 ± 0.15 (0.56 – 0.96) 0.68	6
Jack fruit		1.07 ± 0.21 (0.73 – 1.35) 1.04	0.58 ± 0.12 (0.46 – 0.77) 0.56	0.77 ± 0.16 (0.46 – 0.93) 0.79	6
Longan	Kalokbew	1.08 ± 0.14 (0.94 – 1.34) 1.07	0.69 ± 0.09 (0.59 – 0.84) 0.67	0.68 ± 0.09 (0.55 – 0.74) 0.72	6
Longkong		1.00 ± 0.07 (0.93 – 1.13) 0.98	1.22 ± 0.19 (0.88 – 1.44) 1.26	0.58 ± 0.11 (0.41 – 0.72) 0.59	6

Table 15 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g dry wt.)			N
		Iron	Zinc	Copper	
Lychee	Hohnghooway*	1.20 ± 0.05 (1.12 – 1.23) 1.23	0.87 ± 0.09 (0.80 – 1.02) 0.86	1.04 ± 0.08 (0.96 – 1.12) 1.02	5
	Jackkrapat	0.85 ± 0.12 (0.69 – 0.97) 0.86	0.70 ± 0.19 (0.40 – 0.91) 0.69	0.61 ± 0.13 (0.40 – 0.74) 0.66	6
Mango	Kheosawoei(unripe)	0.82 ± 0.10 (0.68 – 0.97) 0.82	0.44 ± 0.07 (0.34 – 0.53) 0.45	0.60 ± 0.33 (0.44 – 1.28) 0.47	6
	Nahmdawgmai(ripe)	0.75 ± 0.09 (0.60 – 0.85) 0.75	0.37 ± 0.11 (0.24 – 0.55) 0.35	0.38 ± 0.06 (0.32 – 0.46) 0.38	6
	Rad (unripe)	0.76 ± 0.20 (0.57 – 1.14) 0.71	0.42 ± 0.11 (0.33 – 0.57) 0.37	0.89 ± 1.04 (0.28 – 3.01) 0.53	6

Table 15 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g dry wt.)			N
		Iron	Zinc	Copper	
Mangosteen		0.64 ± 0.09 (0.56 – 0.76) 0.61	0.47 ± 0.12 (0.30 – 0.61) 0.46	0.48 ± 0.08 (0.35 – 0.61) 0.48	6
Orange	Clementine	0.88 ± 0.14 (0.73 – 1.05) 0.89	0.42 ± 0.21 (0.24 – 0.81) 0.36	0.55 ± 0.08 (0.49 – 0.65) 0.53	6
	Sai-nuhm-phung	0.86 ± 0.14 (0.71 – 1.06) 0.82	0.33 ± 0.09 (0.28 – 0.50) 0.28	0.33 ± 0.06 (0.28 – 0.43) 0.32	6
Papaya	Khak-dahm	1.43 ± 0.28 (0.97 – 1.75) 1.46	1.02 ± 0.24 (0.78 – 1.46) 0.97	0.39 ± 0.06 (0.29 – 0.49) 0.39	6
Pineapple	Sri-ra-cha	1.17 ± 0.31 (0.86 – 1.72) 1.09	0.46 ± 0.04 (0.40 – 0.53) 0.46	0.34 ± 0.07 (0.26 – 0.40) 0.36	6

Table 15 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g dry wt.)			N
		Iron	Zinc	Copper	
Pomelo	Khao-nahm-peung	1.05 ± 0.17 (0.76 – 1.27) 1.06	0.49 ± 0.18 (0.34 – 0.76) 0.47	0.44 ± 0.08 (0.34 – 0.59) 0.42	6
	Tongdee	1.05 ± 0.22 (0.80 – 1.42) 1.02	0.44 ± 0.15 (0.27 – 0.62) 0.49	0.46 ± 0.07 (0.36 – 0.53) 0.44	6
Rambutan	Rong-rean	0.76 ± 0.12 (0.62 – 0.94) 0.73	0.69 ± 0.05 (0.62 – 0.78) 0.68	0.82 ± 0.16 (0.52 – 0.94) 0.89	6
Rose apple	Toon-klow	1.38 ± 0.21 (1.11 – 1.66) 1.38	0.61 ± 0.12 (0.44 – 0.77) 0.61	0.52 ± 0.11 (0.33 – 0.66) 0.36	6
	Tub- tim-jun	1.01 ± 0.07 (0.90 – 1.09) 1.00	0.42 ± 0.05 (0.36 – 0.45) 0.45	0.39 ± 0.12 (0.27 – 0.54) 0.36	6

Table 15 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g dry wt.)			N
		Iron	Zinc	Copper	
Salacca		1.01 ± 0.22 (0.60 – 1.26) 1.06	0.73 ± 0.10 (0.60 – 0.85) 0.73	0.37 ± 0.24 (0.20 – 0.85) 0.28	6
Sapodilla		0.57 ± 0.06 (0.49 – 0.65) 0.55	0.31 ± 0.05 (0.29 – 0.41) 0.29	0.18 ± 0.03 (0.12 – 0.20) 0.18	6
Star fruit		1.66 ± 0.52 (1.30 – 2.69) 1.51	1.97 ± 0.53 (1.39 – 2.64) 1.99	0.46 ± 0.08 (0.37 – 0.56) 0.46	6
Strawberry		3.01 ± 0.21 (2.77 – 3.25) 3.06	1.42 ± 0.55 (0.86 – 2.39) 1.29	0.59 ± 0.18 (0.38 – 0.86) 0.57	6
Sugar apple	Nahng	0.80 ± 0.06 (0.70 – 0.89) 0.81	0.62 ± 0.17 (0.42 – 0.93) 0.56	0.42 ± 0.05 (0.35 – 0.46) 0.44	6

Table 15 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g dry wt.)			N
		Iron	Zinc	Copper	
Watermelon	Jin-trarah variety (red color)	1.64 ± 0.34 (1.25 – 2.06) 1.52	0.61 ± 0.12 (0.54 – 0.81) 0.54	0.58 ± 0.15 (0.45 - 0.81) 0.54	6
	Jin-trarah variety (yellow color)	1.79 ± 0.27 (1.41 – 2.23) 1.80	0.90 ± 0.31 (0.65 – 1.29) 0.76	0.62 ± 0.09 (0.47 – 0.70) 0.62	6

[1]Data were reported as a mean ± SD of duplicate analysis, range (min-max) and medium (n=6 sample/each kind of fruit). With exception * n=5, **n=2

Table 15 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fruits in syrup)	Micro-mineral contents (mg/100 g dry wt)			N
	Iron	Zinc	Copper	
Fruit cocktail or fruit salad **	0.85 ± 0.07	0.52 ± 0.47	0.26 ± 0.10	2
	(0.80 – 0.89)	(0.19 – 0.85)	(0.19 – 0.33)	
	0.85	0.52	0.26	
Longan	0.70 ± 0.07	0.31 ± 0.04	0.37 ± 0.02	6
	(0.62 – 0.81)	(0.29 – 0.38)	(0.55 – 0.74)	
	0.69	0.29	0.72	
Lychee	0.94 ± 0.15	0.40 ± 0.05	0.43 ± 0.02	6
	(0.75 – 1.19)	(0.35 – 0.48)	(0.40 – 0.44)	
	0.90	0.40	0.44	
Rambutan	0.74 ± 0.20	0.28 ± 0.08	0.41 ± 0.07	6
	(0.44 – 0.97)	(0.19 – 0.39)	(0.34 – 0.48)	
	0.77	0.29	0.41	

[1]Data were reported as a mean ± SD of duplicate analysis, range (min-max) and medium (n=6 sample/each kind of fruit). With exception * n=5, **n=2

Table 16 Micro-mineral contents in fresh fruits and fruits in syrup[1]

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g edible portion)			N
		Iron	Zinc	Copper	
Apple	Fuji	0.12 ± 0.01 (0.11 - 0.14) 0.12	0.05 ± 0.02 (0.03 - 0.07) 0.04	0.06 ± 0.01 (0.05 - 0.06) 0.06	6
	Granny Smith	0.16 ± 0.02 (0.13 - 0.18) 0.16	0.04 ± 0.01 (0.02 - 0.06) 0.04	0.06 ± 0.01 (0.04 - 0.08) 0.06	6
Banana (ripe)	Hawm	0.24 ± 0.02 (0.22 - 0.28) 0.23	0.12 ± 0.02 (0.09 - 0.13) 0.12	0.11 ± 0.02 (0.08 - 0.13) 0.11	6
	Kai	0.26 ± 0.02 (0.22 - 0.27) 0.27	0.17 ± 0.04 (0.11 - 0.21) 0.17	0.14 ± 0.03 (0.11 - 0.20) 0.12	6
	Nahm-wah	0.33 ± 0.04 (0.29 - 0.38) 0.33	0.14 ± 0.03 (0.11 - 0.20) 0.14	0.10 ± 0.03 (0.08 - 0.15) 0.10	6

Table 16 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g edible portion)			N
		Iron	Zinc	Copper	
Chinese pear	Hawm	0.23 ± 0.01 (0.22 - 0.24) 0.23	0.09 ± 0.04 (0.04 - 0.14) 0.07	0.08 ± 0.01 (0.07 - 0.10) 0.08	6
	Namphung	0.08 ± 0.01 (0.07 - 0.09) 0.07	0.07 ± 0.01 (0.05 - 0.09) 0.06	0.07 ± 0.01 (0.06 - 0.09) 0.07	6
Dragon fruit	Vietnam	0.21 ± 0.01 (0.20 - 0.23) 0.21	0.20 ± 0.01 (0.19 - 0.21) 0.20	0.06 ± 0.01 (0.05 - 0.08) 0.05	6
Durain	Chanee	0.32 ± 0.07 (0.23 - 0.40) 0.33	0.27 ± 0.08 (0.16 - 0.40) 0.26	0.22 ± 0.03 (0.18 - 0.26) 0.22	6
	Mawntong	0.21 ± 0.07 (0.11 - 0.33) 0.21	0.17 ± 0.07 (0.08 - 0.27) 0.17	0.21 ± 0.09 (0.12 - 0.32) 0.21	6

Table 16 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g edible portion)			N
		Iron	Zinc	Copper	
Grape	Green	0.20 ± 0.09 (0.13 - 0.38) 0.18	0.08 ± 0.03 (0.06 - 0.13) 0.07	0.28 ± 0.19 (0.05 - 0.56) 0.29	6
Guava	Pan-seetong	0.15 ± 0.01 (0.14 - 0.17) 0.15	0.10 ± 0.04 (0.08 - 0.18) 0.09	0.09 ± 0.02 (0.07 - 0.12) 0.09	6
Jack fruit		0.28 ± 0.06 (0.19 - 0.35) 0.27	0.15 ± 0.03 (0.12 - 0.20) 0.15	0.20 ± 0.04 (0.12 - 0.24) 0.21	6
Longan	Kalokbew	0.22 ± 0.03 (0.19 - 0.27) 0.22	0.14 ± 0.02 (0.12 - 0.17) 0.14	0.14 ± 0.02 (0.11 - 0.15) 0.15	6
Longkong		0.20 ± 0.01 (0.18 - 0.22) 0.19	0.24 ± 0.04 (0.17 - 0.28) 0.25	0.11 ± 0.02 (0.08 - 0.14) 0.12	6

Table 16 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g edible portion)			N
		Iron	Zinc	Copper	
Lychee	Hohnghooway*	0.22 ± 0.01 (0.21 - 0.23) 0.23	0.16 ± 0.02 (0.15 - 0.19) 0.16	0.19 ± 0.02 (0.18 - 0.21) 0.19	5
	Jackkrapat	0.15 ± 0.02 (0.12 - 0.17) 0.15	0.12 ± 0.03 (0.07 - 0.16) 0.12	0.11 ± 0.02 (0.07 - 0.13) 0.12	6
Mango	Kheosawoei(unripe)	0.17 ± 0.02 (0.14 - 0.20) 0.17	0.09 ± 0.01 (0.07 - 0.11) 0.09	0.12 ± 0.07 (0.09 - 0.26) 0.10	6
	Nahmdawgmai(ripe)	0.15 ± 0.02 (0.12 - 0.17) 0.15	0.07 ± 0.02 (0.05 - 0.11) 0.07	0.08 ± 0.01 (0.06 - 0.09) 0.08	6
	Rad (unripe)	0.13 ± 0.04 (0.10 - 0.20) 0.13	0.07 ± 0.02 (0.06 - 0.10) 0.07	0.16 ± 0.18 (0.05 - 0.53) 0.09	6

Table 16 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g edible portion)			N
		Iron	Zinc	Copper	
Mangosteen		0.13 ± 0.02 (0.11 - 0.15) 0.12	0.09 ± 0.02 (0.06 - 0.12) 0.09	0.10 ± 0.02 (0.07 - 0.12) 0.10	6
Orange	Clementine	0.11 ± 0.02 (0.09 - 0.13) 0.11	0.05 ± 0.03 (0.03 - 0.10) 0.05	0.07 ± 0.01 (0.06 - 0.08) 0.07	6
	Sai-nuhm-phung	0.12 ± 0.02 (0.10 - 0.15) 0.12	0.05 ± 0.01 (0.04 - 0.07) 0.04	0.05 ± 0.01 (0.04 - 0.06) 0.05	6
Papaya	Khak-dahm	0.15 ± 0.03 (0.10 - 0.18) 0.15	0.11 ± 0.03 (0.08 - 0.15) 0.10	0.04 ± 0.01 (0.03 - 0.05) 0.04	6
Pineapple	Sri-ra-cha	0.18 ± 0.05 (0.13 - 0.26) 0.17	0.07 ± 0.01 (0.06 - 0.08) 0.07	0.05 ± 0.01 (0.04 - 0.06) 0.06	6

Table 16 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g edible portion)			N
		Iron	Zinc	Copper	
Pomelo	Khao-nahm-peung	0.12 ± 0.02 (0.09 - 0.15) 0.13	0.06 ± 0.02 (0.04 - 0.09) 0.06	0.05 ± 0.01 (0.04 - 0.07) 0.05	6
	Tongdee	0.12 ± 0.02 (0.09 - 0.16) 0.12	0.05 ± 0.02 (0.03 - 0.07) 0.06	0.05 ± 0.01 (0.04 - 0.06) 0.05	6
Rambutan	Rong-rean	0.15 ± 0.02 (0.12 - 0.18) 0.14	0.13 ± 0.01 (0.12 - 0.15) 0.13	0.16 ± 0.03 (0.10 - 0.18) 0.17	6
Rose apple	Toon-klow	0.13 ± 0.02 (0.10 - 0.15) 0.13	0.06 ± 0.01 (0.04 - 0.07) 0.06	0.05 ± 0.01 (0.03 - 0.06) 0.05	6
	Tub- tim-jun	0.11 ± 0.01 (0.10 - 0.12) 0.11	0.05 ± 0.01 (0.04 - 0.05) 0.05	0.04 ± 0.01 (0.03 - 0.06) 0.04	6

Table 16 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g edible portion)			N
		Iron	Zinc	Copper	
Salacca		0.20 ± 0.04 (0.12 - 0.25) 0.21	0.15 ± 0.02 (0.12 - 0.17) 0.15	0.07 ± 0.05 (0.04 - 0.17) 0.06	6
Sapodilla		0.14 ± 0.01 (0.12 - 0.16) 0.14	0.08 ± 0.01 (0.07 - 0.10) 0.07	0.04 ± 0.01 (0.03 - 0.05) 0.05	6
Star fruit		0.18 ± 0.06 (0.14 - 0.29) 0.16	0.21 ± 0.06 (0.15 - 0.29) 0.22	0.05 ± 0.01 (0.04 - 0.06) 0.05	6
Strawberry		0.32 ± 0.02 (0.29 - 0.34) 0.32	0.15 ± 0.06 (0.09 - 0.25) 0.14	0.06 ± 0.02 (0.04 - 0.09) 0.06	6
Sugar apple	Nahng	0.21 ± 0.02 (0.18 - 0.23) 0.21	0.16 ± 0.05 (0.11 - 0.24) 0.15	0.11 ± 0.01 (0.09 - 0.12) 0.12	6

Table 16 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	Micro-mineral contents (mg/100 g edible portion)			N
		Iron	Zinc	Copper	
Watermelon	Jin-trarah variety (red color)	0.18 ± 0.04 (0.14 - 0.23) 0.17	0.07 ± 0.01 (0.06 - 0.09) 0.06	0.07 ± 0.02 (0.05 - 0.09) 0.06	6
	Jin-trarah variety (yellow color)	0.15 ± 0.02 (0.12 - 0.19) 0.15	0.08 ± 0.03 (0.06 - 0.11) 0.07	0.05 ± 0.01 (0.04 - 0.06) 0.05	6

[1]Data were reported as a mean ± SD of duplicate analysis, range (min-max) and medium (n=6 sample/each kind of fruit). With exception * n=5, **n=2

Table 16 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fruits in syrup)	Micro-mineral contents (mg/100 g edible portion)			N
	Iron	Zinc	Copper	
Fruit cocktail or fruit salad **	0.18 ± 0.01 (0.17 - 0.19) 0.18	0.11 ± 0.10 (0.04 - 0.18) 0.11	0.06 ± 0.02 (0.04 - 0.07) 0.06	2
Longan	0.15 ± 0.01 (0.13 - 0.17) 0.15	0.07 ± 0.01 (0.06 - 0.08) 0.06	0.08 ± 0.00 (0.07 - 0.08) 0.08	6
Lychee	0.21 ± 0.03 (0.17 - 0.27) 0.21	0.09 ± 0.01 (0.08 - 0.11) 0.09	0.10 ± 0.00 (0.09 - 0.10) 0.10	6
Rambutan	0.15 ± 0.04 (0.09 - 0.20) 0.16	0.06 ± 0.02 (0.04 - 0.08) 0.06	0.09 ± 0.01 (0.07 - 0.10) 0.09	6

[1]Data were reported as a mean ± SD of duplicate analysis, range (min-max) and medium (n=6 sample/each kind of fruit). With exception * n=5, **n=2

Table 17 Micro-mineral contents in fresh fruits and fruits in syrup[1]

English name (Fresh fruits)	Variety	One portion (g)[2]	Micro-mineral contents (mg/portion of weight)			N
			Iron	Copper	Zinc	
Apple	Fuji	102	0.1	0.06	0.1	6
	Granny Smith	102	0.2	0.06	0	6
Banana (ripe)	Hawm	53	0.1	0.06	0.1	6
	Kai	48	0.1	0.07	0.1	6
	Nahm-wah	53	0.2	0.05	0.1	6
Chinese pear	Hawm	136	0.3	0.11	0.1	6
	Namphung	135	0.1	0.10	0.1	6
Dragon fruit	Vietnam	120	0.2	0.07	0.2	6
Durain	Chanee	58	0.2	0.13	0.2	6
	Mawntong	50	0.1	0.10	0.1	6
Grape	Green	93	0.2	0.26	0.1	6
Guava	Pan-seetong	123	0.2	0.11	0.1	6
Jack fruit		61	0.2	0.12	0.1	6

Table 17 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	One portion (g)[2]	Micro-mineral contents (mg/portion of weight)			N
			Iron	Copper	Zinc	
Longan	Kalokbew	86	0.2	0.12	0.1	6
Longkong		94	0.2	0.11	0.2	6
Lychee	Hohnghooway*	98	0.2	0.19	0.2	5
	Jackkrapat	78	0.1	0.08	0.1	6
Mango	Kheosawoei(unripe)	75	0.1	0.09	0.1	6
	Nahmdawgmai(ripe)	79	0.1	0.06	0.1	6
	Rad (unripe)	76	0.1	0.12	0.1	6
Mangosteen		77	0.1	0.07	0.1	6
Orange	Clementine	101	0.1	0.07	0.1	6
	Sai-nuhm-phung	122	0.2	0.06	0.1	6
Papaya	Khak-dahm	130	0.2	0.05	0.1	6
Pineapple	Sri-ra-cha	101	0.2	0.05	0.1	6

Table 17 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	One portion (g)[2]	Micro-mineral contents (mg/portion of weight)			N
			Iron	Copper	Zinc	
Pomelo	Khao-nahm-phung	92	0.1	0.05	0.1	6
	Tongdee	125	0.2	0.06	0.1	6
Rambutan	Rong-rean	75	0.1	0.12	0.1	6
Rose apple	Toon-klow	205	0.3	0.10	0.1	6
	Tub- tim-jun	152	0.2	0.07	0.1	6
Salacca		78	0.2	0.06	0.1	6
Sapodilla		69	0.1	0.03	0.1	6
Star fruit		159	0.3	0.08	0.3	6
Strawberry		180	0.6	0.11	0.3	6
Sugar apple	Nahng	57	0.1	0.06	0.1	6

Table 17 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fresh fruits)	Variety	One portion (g)[2]	Micro-mineral contents (mg/portion of weight)			N
			Iron	Copper	Zinc	
Watermelon	Jin-trarah variety (red color)	170	0.3	0.11	0.1	6
	Jin-trarah variety (yellow color)	188	0.3	0.10	0.1	6

[1]Data were reported as a mean of duplicate analysis (n=6). With exception * n=5, **n=2

[2] One portion of fresh and canned fruits was calculated by based on 15 gram of carbohydrate that recommended from the food exchange list (68)

Table 17 Micro-mineral contents in fresh fruits and fruits in syrup[1] (Continued)

English name (Fruits in syrup)	One portion (g)[2]	Micro-mineral contents (mg/portion of weight)			N
		Iron	Copper	Zinc	
Fruit cocktail or fruit salad **	91	0.2	0.05	0.1	2
Longan	71	0.1	0.06	0.1	6
Lychee	70	0.2	0.07	0.1	6
Rambutan	63	0.1	0.05	0	6

[1]Data were reported as a mean of duplicate analysis (n=6). With exception * n=5, **n=2

[2] One portion of fresh and canned fruits was calculated by based on 15 gram of carbohydrate that recommended from the food exchange list (68)

5.4 Total polyphenol, Tannin, and Catechin Content Analysis

The total polyphenol content and the composition of total polyphenol, tannin and catechin of fresh fruits and fruits in syrup were shown in Table 18 (per 100 g dry wt). All of them were analyzed in freeze dried form. The polyphenol, tannin, catechin content was determined in term of mg/100 g dry basis and then they were converted to mg/100 g edible portion as shown in table 18.

In fresh fruits, the total polyphenol, tannin and catechin contents ranged from 45.44 to 2110.62 mg GAE/100 g dry basis for total polyphenol, 3.24 to 167.53 mg tannic acid equivalent /100 g dry basis for tannin and 0.13 to 81.82 mg catechin equivalent/100 g dry basis for catechin, respectively. In canned fruits, the contents of total polyphenol and tannin are between 116.06 to 183.66 mgGAE/100 g dry basis and 64.92 to 79.47 mg tannic acid equivalent /100 g dry basis. Comparison among the amount of polyphenol content of all fresh fruit varieties in this study found that sugar apple (Nahng variety), star fruit and strawberry was the highest source of total polyphenol and tannin content by giving the values about 1246.23 to 2110.62 mgGAE/100 g dry basis and 84.83 to 167.53 mg tannic acid equivalent /100 g dry basis. Catechin content was not found in unripe mango (Kheosawoei variety), mangosteen, ripe papaya (Kaah-dahm variety), strawberry, fruit cocktail, longan in syrup, lychee in syrup and rambutan in syrup. Comparison between tannin and catechin contents in fresh fruits and fruits in syrup, the results showed that the tannin contents were higher than the catechin contents with range values. A highest source of catechin content was found in chinese pear (Hawm variety), sapodilla, lychee (Jackkrapat variety), star fruit and sugar apple (Nahng variety) (20.50 to 82.81 mg catechin equivalent /100 g dry basis). Base on the Quartile deviation, total polyphenol can categorize into three levels; High level was more than 448.82; medium level ranged from 187.80 to 448.82; low level was lower than 187.80 mgGAE/100 g dry basis. The high amount of total polyphenol was found in grape (Green variety), unripe mango (Rad variety), orange (both Sai-nuhm-phung and Clementine varieties), longan (Kalokbew variety), lychee (Hohnghooway variety), durian (Mawntong variety), apple (Granny Smith variety), lychee (Jackkrapat variety) and guava (Pan-seetong variety) ranging from 444.03 to 859.97 mgGAE/100 g dry basis. The moderate amount (189.18 to 438.70 mgGAE/100 g dry basis) of total polyphenol was found in longkong,

chinese pear (Hawm variety), sapodilla, watermelon (Jin-trarah red variety), rose apple (Toon-klow variety), watermelon (Jin-trarah yellow variety), pomelo (Tong-dee variety), ripe banana (Nahm-wah variety), unripe mango (Kheosawoei variety), pomelo (Khao-nahm-phung variety), ripe banana (Kai variety), pineapple (Sri-ra-cha variety), durian (Chanee variety), rambutan (Rong-rean variety), salacca, ripe banana (Hawm variety), ripe mango (Nahmdawgmai variety), dragon fruit (Vietnam variety) and mangosteen. Low level was found in ripe papaya (Khak-dahm variety), chinese pear (Namphung variety), rambutan in syrup, longan in syrup, apple (Fuji variety), rose apple (Tub-tim-jun variety), lychee in syrup, jackfruit and fruit salad which ranged from 45.44 to 183.66 mgGAE/100 g dry basis.

Tannin content can divided into three levels by using the Quartile deviation, high level (more than 73.76 mg/100 g dry basis), medium level (ranged from 10.29 to 73.76 mg/100 g dry basis), and low level (less than 10.29 mg/100 g dry basis). The high level (73.87 to 167.53 mg/100 g dry basis) was found in lychee in syrup, unripe mango (Kheosawoei variety), rambutan in syrup, unripe mango (Rad variety), longan in syrup, star fruit, sapodilla, strawberry, ripe mango (Nahm-dawg-mai variety) and sugar apple (Nahng variety). Medium level (10.50 to 73.65 mg/100 g dry basis) was found in salacca, apple (Granny Smith variety), chinese pear (Namphung variety), dragon fruit (Vietnam variety), ripe papaya (Khak-dahm variety), apple (Fuji variety), rambutan (Rong-rean variety), durian (both Chanee, Mawntong varieties), ripe banana (Kai variety), longan (Kalokbew variety), lychee (Hohnghooway variety), rose apple (Tub-tim-jun variety), chinese pear (Hawm variety), grape (Green variety), ripe banana (Nahm-wah variety), rose apple (Toon-klow variety), guava (Pan-seetong variety), fruit salad, watermelon (Jin-trarah yellow variety) and lychee (Jackkrapat variety). Low level (3.24 to 10.08 mg/100 g dry basis) was found in jackfruit, pineapple (Sri-ra-cha variety), longkong, orange (Sai-nuhm-phung variety), pomelo (Khao-nahm-phung and Tongdee varieties), mangosteen, watermelon (Jin-trarah red variety), ripe banana (Hawm variety) and orange (Clementine variety).

For catechin content, the Quartile deviation was use to divide catechin content into three levels. High level was more than 7.85 mg/100 g dry basis, medium level ranged from 0.67 to 7.85 mg/100 g dry basis and low level was less than 0.67 mg/100 g dry basis. The high amount of catechin (7.91 to 13.42 mg/100 g dry basis) was found

in lychee (Hohnghooway variety), rose apple (Toon-klow variety), guava (Pan-seetong variety), apple (Fuji variety), grape (Green variety), chinese pear (Namphung variety) and ripe banana (Nahmwah variety). The moderate level (0.74 to 7.68 mg/100 g dry basis) was found in durian (Mawntong variety), longan (Kalokbew variety), durian (Chanee variety), orange (Clementine variety), banana (Hawm variety), pomelo (Khao-nahm-peung variety), salacca, dragon fruit (Vietnam variety), ripe mango (Nahmdawgmai variety), rose apple (Tub-tim-jun variety), ripe banana (Kai variety), rambutan (Rong-rean variety), apple (Granny Smith variety) and longkong. Low level was found in watermelon (Jin-trarah variety both in yellow and red), orange (Sai-nuhm-phung variety), jackfruit, pomelo (Tongdee variety), pineapple (Sri-sa-cha variety) and unripe mango (Rad variety) which ranged from 0.13 to 0.65 mg/100 g dry basis.

Data on the total polyphenol, tannin and catechin content per one portion were shown in Table 19. The calculation of polyphenol, tannin and catechin content to one portion of each fruits were 6.07 to 397.13 mgGAE / portion for total polyphenol, 0.58 to 28.49 mg tannic acid equivalent/portion for tannin and 0.02 to 12.79 mg catechin equivalent / portion for catechin, respectively. Strawberry was the highest source of total polyphenol and tannin (397.13 mgGAE/portion and tannin 28.49 mg tannic acid equivalent /portion) while star fruit is the greatest source of catechin (12.79 mg catechin equivalent/portion). The polyphenol and tannin content among fruits in syrup of present study showed that the highest polyphenol and tannin contents were found in fruit cocktail (polyphenol: 35.49 mg GAE/portion, tannin: 12.54 mg tannic acid equivalent/ portion).

Table 18 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1, 2]

English name (Fresh fruits)	Wet basis			Dry basis		
	Polyphenol	Tannin	Catechin	Polyphenol	Tannin	Catechin
Apple :						
Fuji variety	24.41 ± 6.74	2.21 ± 1.09	1.41 ± 0.84	164.09 ± 45.28	14.84 ± 7.31	9.44 ± 5.67
	(17.76 – 35.45)	(1.07 – 3.78)	(0.65 – 2.46)	(119.37 – 238.27)	(7.19 – 25.14)	(4.37 – 16.53)
	23.48	1.76	1.33	157.81	11.80	8.91
Granny Smith	90.24 ± 117.12	1.76 ± 0.76	0.79 ± 1.39	646.04 ± 838.48	12.58 ± 5.42	5.62 ± 9.96
variety	(27.52 – 328.60)	(0.88 – 2.99)	(0.05 – 3.61)	(197.02 -2352.46)	(6.30 – 21.41	(0.36 – 25.84)
	46.02	1.54	0.31	329.46	11.00	2.18
Banana						
(ripe) :	90.35 ± 22.37	2.16 ± 0.97	0.34 ± 0.50	368.3 ± 91.32	8.80 ± 3.97	1.37 ± 2.04
Hawm variety	(63.77 – 121.76)	(1.04 – 3.69)	(0.00 – 1.22)	(260.39 – 497.18)	(4.25 – 15.07)	(0.00 – 4.98)
	95.57	1.87	0.08	390.24	7.62	0.33
Kai variety	93.48 ± 24.70	5.23 ± 0.74	1.28 ± 0.87	329.50 ± 87.08	18.42 ± 2.62	4.50 ± 3.08
	(57.11 – 122.12)	(4.45 – 6.21)	(0.00 – 2.57)	(201.32 – 430.48)	(15.69 – 21.89)	(0.00 – 9.06)
	90.11	5.04	1.20	317.63	17.75	4.21

Table 18 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1, 2] (Continued)

English name	Wet basis			Dry basis		
(Fresh fruits)	Polyphenol	Tannin	Catechin	Polyphenol	Tannin	Catechin
Banana (ripe):						
Nahm-wah	96.09 ± 24.90	13.39 ± 7.36	4.64 ± 3.10	291.72 ± 75.61	40.65 ± 22.35	14.10 ± 9.42
variety	(60.11 – 124.84)	(4.57 – 24.23)	(1.00 – 9.12)	(182.49 – 379.01)	(13.87 – 73.56)	(3.04 – 27.69)
	97.12	11.74	4.27	294.84	35.64	12.96
Chinese pear :						
Hawm variety	29.75 ± 7.05	4.71 ± 3.00	2.99 ± 2.65	203.94 ± 48.29	32.25 ± 20.59	20.50 ± 18.16
	(21.17 – 39.70)	(1.94 – 8.61)	(0.00 – 5.75)	(145.12 – 272.14)	(13.31 – 59.02)	(0.00 – 39.42)
	30.50	4.29	3.03	209.04	29.41	20.77
Namphung	14.63 ± 3.10	1.81 ± 0.27	1.85 ± 0.83	106.32 ± 22.51	13.14 ± 1.98	13.42 ± 6.04
variety	(9.12 – 17.57)	(1.55 – 2.31)	(0.96 – 3.03)	(66.26 – 127.66)	(11.26 – 16.78)	(6.98 – 22.02)
	15.00	1.78	1.52	108.95	12.93	11.04
Dragon fruit :	64.04 ± 22.77	1.99 ± 0.42	0.41 ± 0.32	425.47 ± 151.27	13.23 ± 2.79	2.71 ± 2.13
Vietnam	(23.15 – 87.93)	(1.42 – 2.48)	(0.00 – 0.96)	(153.80 – 584.19)	(9.43 – 16.48)	(0.00 – 6.38)
variety	68.15	2.00	0.36	452.77	13.25	2.39

Table 18 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1, 2] (Continued)

English name (Fresh fruits)	Wet basis			Dry basis		
	Polyphenol	Tannin	Catechin	Polyphenol	Tannin	Catechin
Durain :						
Chanee variety	115.49 ± 41.81	5.25 ± 0.91	0.41 ± 1.00	347.96 ± 125.97	15.81 ± 2.74	1.23 ± 3.01
	(80.45 – 184.60)	(4.11 – 6.67)	(0.00 – 2.45)	(242.39 – 556.19)	(12.38 – 20.10)	(0.00 – 7.38)
	99.69	5.17	0.00	300.36	15.56	0.00
Mawntong	176.61 ± 84.45	4.87 ± 1.23	0.22 ± 0.27	606.95 ± 290.23	16.72 ± 4.23	0.74 ± 0.91
variety	(75.19 – 315.92)	(3.16 – 6.92)	(0.00 – 0.57)	(258.40–1085.70)	(10.86 – 23.78)	(0.00 – 1.96)
	176.43	4.73	0.11	606.31	16.26	0.38
Grape :	77.48 ± 12.02	6.27 ± 2.37	1.94 ± 1.23	444.03 ± 68.90	35.93 ± 13.56	11.12 ± 7.04
Green variety	(59.24 – 91.84)	(4.11 – 10.35)	(0.00 – 3.76)	(339.48 – 526.30)	(23.55 – 59.31)	(0.00 – 21.55)
	75.66	5.32	1.93	433.55	30.46	11.06
Guava :	107.77 ± 23.74	7.06 ± 2.00	1.15 ± 0.65	859.97 ± 189.43	56.35 ± 15.93	9.20 ± 5.17
Pan-seetong	(82.44 – 143.27)	(4.80 – 10.57)	(0.50 – 2.18)	(657.85–1143.26)	(38.30 – 84.35)	(3.99 – 17.40)
variety	102.25	6.55	1.09	815.89	52.27	8.66

Table 18 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1, 2] (Continued)

English name (Fresh fruits)	Wet basis			Dry basis		
	Polyphenol	Tannin	Catechin	Polyphenol	Tannin	Catechin
Jack fruit	47.21 ± 11.24	0.84 ± 0.43	0.11 ± 0.13	182.13 ± 43.36	3.24 ± 1.67	0.41 ± 0.51
	(32.49 – 61.38)	(0.34 – 1.28)	(0.00 – 0.28)	(125.35 – 236.81)	(1.31 – 4.94)	(0.00 – 1.08)
	48.20	0.84	0.05	185.96	3.22	0.19
Longan :	100.03 ± 16.33	5.53 ± 0.85	0.15 ± 0.23	495.86 ± 80.93	27.42 ± 4.20	0.74 ± 1.15
Kalokbew	(86.73 – 123.20)	(4.23 – 6.44)	(0.00 – 0.50)	(429.92 – 610.71)	(20.97 – 31.92)	(0.00 – 2.48)
variety	91.65	5.80	0.00	454.29	28.73	0.00
Longkong	36.74 ± 5.15	0.92 ± 0.23	1.49 ± 3.21	189.18 ± 26.53	4.72 ± 1.19	7.68 ± 16.54
	(28.89 – 43.89)	(0.71 – 1.22)	(0.00 – 8.04)	(148.76 – 226.00)	(3.66 – 6.28)	(0.00 – 41.40)
	36.26	0.86	0.25	186.71	1.29	1.29
Lychee :						
Hohnghooway	111.83 ± 12.48	5.89 ± 2.43	1.77 ± 3.17	498.39 ± 251.35	26.24 ± 17.34	7.91 ± 15.64
variety*	(99.27 – 132.80)	(2.33 – 9.20)	(0.00 – 7.31)	(0.00 – 710.24)	(0.00 – 49.20)	(0.00 – 39.10)
	109.34	5.97	0.00	584.77	31.93	0.00

Table 18 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1, 2] (Continued)

English name (Fresh fruits)	Wet basis			Dry basis		
	Polyphenol	Tannin	Catechin	Polyphenol	Tannin	Catechin
Jackkrapat variety	117.37 ± 37.63 (76.14 – 182.01) 107.91	12.89 ± 11.36 (3.47 – 32.56) 8.60	8.93 ± 9.27 (1.52 – 24.60) 4.96	670.80 ± 215.06 (435.17–1040.26) 616.72	73.65 ± 64.93 (19.83 –186.09) 49.15	51.01 ± 52.99 (8.69–140.60) 28.32
Mango :						
Kheosawoei (unripe) variety	65.18 ± 15.60 (45.50 – 89.98) 64.15	15.36 ± 5.52 (8.34 – 22.94) 14.69	ND	315.19 ± 75.45 (220.04 – 435.14) 310.20	74.28 ± 26.71 (40.33– 110.94) 71.04	ND
Nahmdawgmai (ripe) variety	79.24 ± 11.63 (60.11 – 92.73) 79.75	32.40 ± 11.73 (16.86 – 42.28) 37.47	0.75 ± 1.29 (0.00 – 3.14) 0.00	397.13 ± 58.26 (301.25 – 464.73) 399.66	162.39 ± 58.79 (84.50– 211.89) 187.76	3.78 ± 6.48 (0.00 – 15.74) 0.00
Rad (unripe) variety	81.46 ± 18.80 (59.77 – 110.79) 76.09	13.82 ± 12.07 (1.25 – 31.79) 12.65	0.12 ± 0.19 (0.00 – 0.45) 0.00	463.17 ± 106.92 (339.86 – 629.97) 432.63	78.59 ± 68.64 (7.11 – 180.76) 71.93	0.65 ± 1.08 (0.00 – 2.56) 0.00

Table 18 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1, 2] (Continued)

English name (Fresh fruits)	Wet basis			Dry basis		
	Polyphenol	Tannin	Catechin	Polyphenol	Tannin	Catechin
Mangosteen	86.90 ± 12.90	1.18 ± 1.76		438.70 ± 65.11	5.95 ± 8.89	
	(66.59 – 97.91)	(0.00 – 3.63)	ND	(336.17 – 494.29)	(0.00 – 18.33)	ND
	90.15	0.09		455.09	0.45	
Orange :						
Clementine	61.17 ± 11.45	1.25 ± 0.31	0.16 ± 0.25	494.66 ± 92.64	10.08 ± 2.48	1.32 ± 2.03
variety	(49.39 – 79.02)	(0.77 – 1.66)	(0.00 – 0.54)	(399.43 – 639.06)	(6.23 – 13.42)	(0.00 – 4.37)
	59.66	1.20	0.01	482.49	9.70	0.04
Sai-nuhm-	67.13 ± 20.75	0.69 ± 0.33	0.03 ± 0.07	475.75 ± 147.02	4.89 ± 2.31	0.21 ± 0.52
phung variety	(35.91 – 89.99)	(0.25 – 1.20)	(0.00 – 0.18)	(254.50 – 637.77)	(1.77 – 8.50)	(0.00 – 1.28)
	67.05	0.71	0.00	475.19	5.03	0.00
Papaya :						
Khak-dahm	4.67 ± 0.56	1.52 ± 0.21		45.44 ± 5.44	14.80 ± 2.00	
variety	(4.03 – 5.63)	(1.23 – 1.77)	ND	(39.22 – 54.85)	(11.97 – 17.25)	ND
	4.65	1.53		45.29	14.93	

Table 18 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1,2] (Continued)

English name (Fresh fruits)	Wet basis			Dry basis		
	Polyphenol	Tannin	Catechin	Polyphenol	Tannin	Catechin
Pineapple :						
Sri-ra-cha variety	50.34 ± 23.64 (24.91 – 80.85) 39.76	0.71 ± 0.28 (0.33 – 1.00) 0.73	0.09 ± 0.09 (0.00 -0.24) 0.08	332.94 ± 156.39 (164.77 – 534.78) 262.96	4.67 ± 1.85 (2.18 – 6.61) 4.83	0.61 ± 0.62 (0.00 – 1.59) 0.53
Pomelo :						
Khao-nahm-phung variety	37.87 ± 11.03 (21.82 – 50.31) 41.87	0.63 ± 0.35 (0.23 – 1.10) 0.55	0.20 ± 0.28 (0.00 – 0.72) 0.10	321.04 ± 93.48 (184.97 – 426.48) 354.89	5.31 ± 2.93 (1.95 – 9.32) 4.66	1.72 ± 2.41 (0.00 – 6.10) 0.81
Tongdee variety	32.58 ± 3.26 (28.14 – 36.05) 32.85	0.62 ± 0.18 (0.35 – 0.87) 0.60	0.06 ± 0.12 (0.00 – 0.30) 0.00	289.26 ± 28.90 (249.84 – 320.07) 291.61	5.50 ± 1.56 (3.11 – 7.72) 5.33	0.52 ± 1.07 (0.00 – 2.66) 0.00
Rambutan :						
Rong-rean variety	67.39 ± 19.89 (43.84 – 87.45) 70.71	2.89 ± 2.96 (0.40 – 7.11) 1.33	1.05 ± 1.24 (0.00 – 3.38) 0.74	350.93 ± 103.60 (228.29 – 455.39) 368.22	15.02 ± 15.41 (2.08 – 37.02) 6.90	5.46 ± 6.48 (0.00 – 17.60) 3.85

Table 18 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1,2] (Continued)

English name (Fresh fruits)	Wet basis			Dry basis		
	Polyphenol	Tannin	Catechin	Polyphenol	Tannin	Catechin
Rose apple :						
Toon-klow	24.32 ± 10.00	3.94 ± 3.07	0.72 ± 0.80	268.82 ± 110.58	43.58 ± 33.93	7.92 ± 8.84
variety	(9.51 – 38.18)	(1.10 – 7.84)	(0.00 – 2.05)	(105.14 – 422.11)	(12.20 – 86.68)	(0.00 – 22.66)
	25.45	2.87	0.51	281.32	31.77	5.64
Tub-tim-jun	19.67 ± 13.15	3.46 ± 1.16	0.48 ± 0.25	178.00 ± 119.00	31.29 ± 10.54	4.31 ± 2.30
variety	(7.12 – 43.60)	(1.91 – 5.35)	(0.05 – 0.71)	(64.42 – 394.51)	(17.28 – 48.41)	(0.45 – 6.42)
	16.95	3.31	0.54	153.33	29.95	4.89
Salacca	71.32 ± 8.13	2.09 ± 0.84	0.38 ± 0.88	358.38 ± 40.85	10.50 ± 4.24	1.89 ± 4.42
	(57.51 – 81.13)	(1.16 – 3.19)	(0.00 – 2.17)	(288.99 – 407.69)	(5.83 – 16.03)	(0.00 – 10.90)
	73.60	1.77	0.00	369.85	8.89	0.00
Sapodilla	57.63 ± 14.06	26.31 ± 22.10	11.32 ± 10.05	235.47 ± 57.44	107.50 ± 90.29	46.27 ± 41.05
	(44.12 – 81.92)	(12.36 – 68.95)	(5.13 – 31.66)	(180.28 – 334.73)	(50.50 – 281.74)	(21.70–129.37)
	55.97	16.24	7.86	228.68	66.34	32.10

Table 18 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1,2] (Continued)

English name (Fresh fruits)	Wet basis			Dry basis		
	Polyphenol	Tannin	Catechin	Polyphenol	Tannin	Catechin
Star fruit	148.37 ± 110.72 (18.40 – 278.92) 131.41	9.16 ± 14.04 (1.49 – 37.65) 4.12	8.05 ± 9.83 (0.09 – 21.39) 3.44	1373.99±1025.37 (170.40 – 2582.99) 1216.90	84.83 ± 129.99 (13.80– 348.66) 38.15	74.52 ± 91.05 (0.83– 198.09) 31.81
Strawberry	220.63 ± 91.75 (99.06 – 324.90) 247.53	15.83 ± 3.60 (9.10 – 19.31) 16.33	ND	2110.62 ± 877.7 (947.64 – 3108.10) 2367.95	151.39 ± 34.46 (87.06 – 184.73) 156.22	ND
Sugar apple :						
Nahng variety	322.63 ± 29.00 (278.30 – 348.43) 334.43	43.37 ± 22.68 (16.02 – 67.19) 44.59	21.44 ± 15.02 (4.87 – 42.73) 20.02	1246.23 ± 112.03 (148.76 – 226.00) 1291.82	167.53 ± 87.61 (61.88 – 259.54) 172.22	82.81 ± 58.00 (18.81 – 165.06 77.31
Watermelon :						
Jin-trarah variety (red color)	28.20 ± 21.01 (5.21 – 53.86) 26.36	0.91 ± 0.44 (0.48 – 1.45) 0.79	0.02 ± 0.04 (0.00 – 0.11) 0.00	252.45 ± 188.08 (46.64 – 482.18) 235.94	8.13 ± 3.91 (4.30 – 12.98) 7.07	0.16 ± 0.40 (0.00 – 0.98) 0.00

Table 18 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1,2] (Continued)

English name (Fresh fruits)	Wet basis			Dry basis		
	Polyphenol	Tannin	Catechin	Polyphenol	Tannin	Catechin
Jin-trarah variety (yellow color)	23.44 ± 14.69 (8.62 – 47.40) 22.80	6.19 ± 7.54 (0.21 – 17.10) 2.23	0.01 ± 0.03 (0.00 – 0.07) 0.00	275.08 ± 172.44 (101.15 – 556.23) 267.49	72.68 ± 88.44 (2.46 – 200.66) 26.17	0.13 ± 0.32 (0.00 – 0.79) 0.00

[1]Data were reported as a mean ± SD of duplicate analysis, range (min-max) and medium (n=6 sample/each kind of fruit). With exception * n=5, **n=2. ND = Not de

[2]Polyphenol, Tannin and Catechin expressed to mg GAE/100g, mg tannic acid equivalent/ 100 g, mg catechin equivalent/ 100g, respectively

Table 18 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1] (Continued)

English name	Wet basis			Dry basis		
(Fruits in syrup)	Polyphenol	Tannin	Catechin	Polyphenol	Tannin	Catechin
Fruit cocktail or fruit salad **	39.00 ± 4.24 (36.00 – 42.00) 39.00	13.79 ± 0.04 (13.76 – 13.81) 13.79	ND	183.66 ± 19.98 (169.53 – 197.79) 183.66	64.92 ± 0.17 (64.80 – 65.03) 64.92	ND
Longan	27.75 ± 5.35 (20.80 – 33.80) 27.90	16.65 ± 0.73 (15.50 – 17.74) 16.63	ND	132.42 ± 25.55 (99.25 – 161.29) 133.13	79.47 ± 3.49 (73.96 – 84.65) 79.35	ND
Lychee	40.95 ± 7.07 (29.00 – 48.40) 40.55	16.79 ± 3.62 (9.99 – 20.29) 17.57	ND	180.17 ± 31.09 (127.59 – 212.95) 178.41	73.87 ± 15.92 (43.95 – 89.27) 77.28	ND
Rambutan	24.00 ± 4.68 (17.70 – 30.00) 22.55	15.67 ± 2.61 (12.14 – 19.65) 15.30	ND	116.06 ± 22.64 (85.60 – 145.08) 109.05	75.77 ± 12.61 (58.71 – 95.03) 73.97	ND

[1]Data were reported as a mean ± SD of duplicate analysis, range (min-max) and medium (n=6 sample/each kind of fruit). With exception * n=5, **n=2 ND = Not detected

[2]Polyphenol, Tannin and Catechin was expressed to mg GAE/100g, mg tannic acid equivalent/ 100 g, mg catechin equivalent/ 100g, respectively

Table 19 Polyphenol, Tannin, Catechin contents in fresh and fruit in syrup[1,2] (mg/portion of weight)

English name (Fresh fruits)	Variety	One portion (g)[3]	Total Polyphenol	Tannin	Catechin	N
Apple	Fuji	102	24.91	2.25	1.43	6
	Granny Smith	102	90.24	1.76	0.79	6
Banana (ripe)	Hawm	53	47.89	1.14	0.18	6
	Kai	48	44.87	2.51	0.61	6
	Nahm-wah	53	50.93	7.10	2.46	6
Chinese pear	Hawm	136	40.46	6.40	4.07	6
	Namphung	135	19.76	2.44	2.49	6
Dragon fruit	Vietnam	120	76.85	2.39	0.49	6
Durain	Chanee	58	66.98	3.04	0.24	6
	Mawntong	50	88.01	2.42	0.11	6
Grape	Green	93	72.06	5.83	1.80	6
Guava	Pan-seetong	123	132.56	8.69	1.42	6
Jack fruit		61	28.80	0.51	0.07	6

Table 19 Polyphenol, Tannin, Catechin contents in fresh and fruit in syrup[1,2] (mg/portion of weight) (Continued)

English name (Fresh fruits)	Variety	One portion (g)[3]	Total Polyphenol	Tannin	Catechin	N
Longan	Kalokbew	86	86.03	4.76	0.13	6
Longkong		94	34.53	0.86	1.40	6
Lychee	Hohnghooway*	98	109.59	5.77	1.74	5
	Jackkrapat	78	91.55	10.05	6.96	6
Mango	Kheosawoei (unripe)	75	49.13	11.58	ND	6
	Nahmdawgmai (ripe)	79	62.60	25.60	0.60	6
	Rad (unripe)	76	61.91	10.50	0.09	6
Mangosteen		77	66.91	0.91	ND	6
Orange	Clementine	101	61.78	1.26	0.16	6
	Sai-nuhm-phung	122	81.90	0.84	0.04	6
Papaya	Khak-dahm	130	6.07	1.98	ND	6
Pineapple	Sri-ra-cha	101	50.84	0.71	0.09	6

Table 19 Polyphenol, Tannin, Catechin contents in fresh and fruit in syrup[1,2] (mg/portion of weight) (Continued)

English name (Fresh fruits)	Variety	One portion (g)[3]	Total Polyphenol	Tannin	Catechin	N
Pomelo	Khao-nahm-peung	92	34.84	0.58	0.19	6
	Tongdee	125	40.73	0.78	0.07	6
Rambutan	Rong-rean	75	50.54	2.16	0.79	6
Rose apple	Toon-klow	205	49.96	8.10	1.47	6
	Tub- tim-jun	152	29.90	5.26	0.72	6
Salacca		78	55.63	1.63	0.29	6
Sapodilla		69	39.76	18.15	7.81	6
Star fruit		159	235.91	14.56	12.79	6
Strawberry		180	397.13	28.49	ND	6
Sugar apple	Nahng	57	183.90	24.72	12.22	6
Watermelon	Jin-trarah variety (red color)	170	47.94	1.54	0.03	6
	Jin-trarah variety (yellow color)	188	44.07	11.64	0.02	6

Table 19 Polyphenol, Tannin, Catechin contents in fresh and fruit in syrup[1,2] (mg/portion of weight) (Continued)

English name (Fruits in syrup)	One portion (g)[3]	Total Polyphenol	Tannin	Catechin	N
Fruit cocktail or fruit salad **	91	35.49	12.54	ND	2
Longan	71	19.70	11.82	ND	6
Lychee	70	28.67	11.75	ND	6
Rambutan	63	15.12	9.87	ND	6

[1]Data were reported as a mean of duplicate analysis (n=6 sample/each kind of fruit). With exception * n=5, **n=2 ND = Not detected

[2]Polyphenol, Tannin and Catechin was expressed to mg GAE/100g, mg tannic acid equivalent/ 100 g, mg catechin equivalent/ 100g, respectively

[3] One portion of fresh and canned fruits was calculated by based on 15 gram of carbohydrate that recommended from the food exchange list (68)

5.5 Phytate Content Analysis

The phytate content and the composition of phytate; IP5 and IP6, of fresh fruits and fruits in syrup were shown in Table 20 (per 100 g dry basis and per 100 g edible portion) and Table 21 (per portion). All fruit samples were analyzed in freeze dried forms. The phytate content was reported as milligram per 100 g dry basis and then they were converted to milligram per 100 g edible portion.

The phytate content of fresh fruits ranged from 0.10 to 40.00 mg/100 g dry basis. Phytate content was not found in durian (both in Chanee and Mawntong varieties), papaya (Khak-dahm variety), pineapple (Sri-ra-cha variety), rose apple (Toon-klow variety), salacca, sugar apple (Nahng variety), watermelon (Jin-trarah variety, red color). Lychee (Jackkrapat variety) and dragon fruit (Vietnam variety) were the highest source of phytate (24.55 and 40.00 mg/100 g dry basis, respectively). Base on the Quartile deviation, the data were divided into three levels; High level was more than 10.22 mg/100 g dry basis, medium level was 1.24 to 10.22 mg/100 g dry basis and low level was less than 1.24 mg/100 g dry basis. High level (10.22 to 20.59 mg/100 g dry basis) was found in apple (Fuji variety), rambutan (Rong-rean variety), apple (Granny Smith variety), longkong, pomelo (Tongdee variety) guava (Pan-seetong variety), and strawberry. Medium level was found in mangosteen, ripe banana (Kai variety), watermelon (Jin-trarah variety, yellow), star fruit, grape (Green variety), jackfruit, chinese pear (Hawm variety), orange (Clementine and Sai-nuhm-phung varieties), sapodilla, chinese pear (Namphung variety), pomelo (Khao-nahm-peung variety) and lychee (Hohnghooway variety) which ranged from 1.27 to 9.89 mg/100 g dry basis. Low level (0.10 to 1.24 mg/100 g dry basis) was found in rose apple (Tub-tim-jun variety), ripe banana (Hawm variety), ripe mango (Nahmdawgmai variety), longan (Kalokbew variety), ripe banana (Nahm-wah variety) unripe mango (Rad variety) and unripe mango (Kheosawoei variety).

Phytate content per one portion was highest amount (7.22 mg/ portion) in dragon fruit (Vietnam variety) whereas that of rose apple (Tub-tim-jun variety) was the lowest amount (0.03 mg/portion). In addition, data showed that fresh fruit is poor sources of phytate which ranged from 0.03 to 7.22 mg/portion. However, when consider on the content of phytate all the fruit samples even in form of mg /100g edible portion or mg per 100 g dry basis, it was found that the fruit samples are poor sources of phytate.

Table 20 Phytate content of fresh fruits and fruits in syrup[1]

English name (Fresh fruits)	Wet basis			Dry basis		
	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)
Apple :						
Fuji variety	0.02 ± 0.04	1.50 ± 0.71	1.52 ± 0.69	0.12 ± 0.30	10.10 ± 4.75	10.22 ± 4.61
	(0.00 – 0.11)	(0.81 – 2.79)	(0.91 – 2.79)	(0.00 – 0.74)	(5.46 – 18.76)	(6.10 – 18.76)
	0.00	1.48	1.48	0.00	9.97	9.97
Granny Smith variety	ND	1.69 ± 0.78 (0.68 – 2.59) 1.73	1.69 ± 0.78 (0.68 – 2.59) 1.73	ND	12.12 ± 5.59 (4.86 – 18.55) 12.39	12.12 ± 5.59 (4.86 – 18.55) 12.39
Banana (ripe) :						
Hawm variety	0.07 ± 0.09	0.06 ± 0.11	0.13 ± 0.18	0.27 ± 0.35	0.27 ± 0.44	0.54 ± 0.74
	(0.00 – 0.19)	(0.00 – 0.28)	(0.00 – 0.44)	(0.00 – 0.76)	(0.00 – 1.14)	(0.00 – 1.79)
	0.03	0.02	0.05	0.11	0.08	0.20
Kai variety	0.10 ± 0.08	0.33 ± 0.47	0.43 ± 0.44	0.34 ± 0.27	1.18 ± 1.66	1.52 ± 1.55
	(0.00 – 0.16)	(0.00 – 1.25)	(0.00 – 1.25)	(0.00 – 0.57)	(0.00 – 4.41)	(0.00 – 4.41)
	0.14	0.13	0.28	0.49	0.44	0.98

Table 20 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1](Continued)

English name (Fresh fruits)	Wet basis			Dry basis		
	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)
Nahm-wah variety	0.12 ± 0.10 (0.00 – 0.25) 0.13	0.28 ± 0.22 (0.00 – 0.47) 0.36	0.39 ± 0.31 (0.00 – 0.67) 0.55	0.35 ± 0.31 (0.00 – 0.75) 0.38	0.84 ± 0.67 (0.00 – 1.43) 1.10	1.20 ± 0.94 (0.00 – 2.02) 1.67
Chinese pear :						
Hawm variety	0.02 ± 0.04 (0.00 – 0.10) 0.00	0.75 ± 0.16 (0.49 – 1.00) 0.76	0.77 ± 0.13 (0.59 – 1.00) 0.76	0.11 ± 0.27 (0.00 – 0.66) 0.00	5.17 ± 1.12 (3.38 – 6.87) 5.19	5.28 ± 0.92 (4.04 – 6.87) 5.19
Namphung variety	ND	0.91 ± 0.29 (0.55 – 1.35) 0.91	0.91 ± 0.29 (0.55 – 1.35) 0.91	ND	6.60 ± 2.10 (4.02 – 9.82) 6.59	6.60 ± 2.10 (4.02 – 9.82) 6.59
Dragon fruit : Vietnam variety	1.01 ± 0.91 (0.00 – 2.34) 0.89	5.01 ± 5.16 (0.00 – 12.53) 3.58	6.02 ± 6.04 (0.00 – 14.87) 4.48	6.73 ± 6.06 (0.00 – 15.52) 5.93	33.27 ± 34.26 (0.00–83.27) 23.81	40.00 ± 40.12 (0.00 – 98.79) 29.74

Table 20 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1](Continued)

English name (Fresh fruits)	Wet basis			Dry basis		
	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)
Durain :						
Chanee variety	ND	ND	ND	ND	ND	ND
Mawntong variety	ND	ND	ND	ND	ND	ND
Grape						
Green variety	0.13 ± 0.07	0.50 ± 0.33	0.62 ± 0.40	0.74 ± 0.39	2.84 ± 1.90	3.58 ± 2.27
	(0.07 – 0.24)	(0.18 – 1.08)	(0.25 – 1.33)	(0.38 – 1.38)	(1.03 – 6.21)	(1.41 – 7.60)
	0.11	0.45	0.58	0.65	2.55	3.35
Guava						
Pan-seetong variety	0.27 ± 0.08	2.17 ± 0.88	2.45 ± 0.94	2.18 ± 0.65	17.34 ± 6.99	19.52 ± 7.49
	(0.12 – 0.34)	(1.18 – 3.33)	(1.30 – 3.64)	(0.97 – 2.73)	(9.42 – 26.58)	(10.39 – 29.08)
	0.30	2.05	2.34	2.43	16.39	18.65

Table 20 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1](Continued)

English name	Wet basis			Dry basis		
(Fresh fruits)	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)
Jack fruit	0.11 ± 0.09	1.11 ± 0.19	1.22 ± 0.22	0.41 ± 0.35	4.30 ± 0.72	4.70 ± 0.83
	(0.00 – 0.23)	(0.87 – 1.37)	(0.87 – 1.42)	(0.00 – 0.88)	(3.34 – 5.28)	(3.34 – 5.49)
	0.13	1.11	1.27	0.50	4.30	4.89
Longan						
Kalokbew variety	0.10 ± 0.13	0.01 ± 0.03	0.12 ± 0.14	0.51 ± 0.67	0.07 ± 0.17	0.58 ± 0.71
	(0.00 – 0.34)	(0.00 – 0.09)	(0.00 – 0.34)	(0.00 – 1.68)	(0.00 – 0.42)	(0.00 – 1.68)
	0.07	0.00	0.07	0.34	0.00	0.37
Longkong	0.67 ± 0.20	2.55 ± 0.71	3.22 ± 0.84	3.46 ± 1.01	13.13 ± 3.64	16.59 ± 4.33
	(0.42 – 0.91)	(1.17 – 3.22)	(1.59 – 3.95)	(2.18 – 4.68)	(6.03 – 16.60)	(8.21 – 20.32)
	0.65	2.75	3.46	3.33	14.14	17.82
Lychee :	1.14 ± 0.46	0.71 ± 0.49	1.85 ± 0.93	6.09 ± 2.46	3.80 ± 2.64	9.89 ± 5.00
Hohnghooway*	(0.53 –1.73)	(0.15 – 1.38)	(0.68 – 3.11)	(2.82 – 9.26)	(0.80 – 7.37)	(3.62 – 16.63)
variety	1.28	0.52	1.80	5.72	2.62	8.34

Table 20 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1](Continued)

English name (Fresh fruits)	Wet basis			Dry basis		
	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)
Jackkrapat variety	1.92 ± 0.65 (1.14 – 2.88) 1.98	2.37 ± 1.49 (1.10 – 5.07) 1.75	4.30 ± 2.08 (2.24 – 7.95) 3.67	10.96 ± 3.73 (6.51 – 16.46) 11.30	13.56 ± 8.50 (6.29 – 28.96) 10.02	24.55 ± 11.91 (12.80– 45.42) 20.95
Mango :						
Kheosawoei(unripe) variety	0.05 ± 0.03 (0.00 – 0.08) 0.05	0.21 ± 0.16 (0.00 – 0.48) 0.18	0.26 ± 0.18 (0.00 – 0.56) 0.23	0.24 ± 0.14 (0.00 – 0.38) 0.26	0.99 ± 0.79 (0.00 – 2.33) 0.89	1.24 ± 0.89 (0.00 – 2.71) 1.12
Nahmdawgmai (ripe) variety	0.02 ± 0.03 (0.00 – 0.06) 0..00	0.09 ± 0.14 (0.00 – 0.36) 0.01	0.11 ± 0.17 (0.00 – 0.42) 0.02	0.11 ± 0.15 (0.00 – 0.32) 0.01	0.45 ± 0.72 (0.00 – 1.80) 0.07	0.55 ± 0.86 (0.00 – 2.12) 0.08
Rad (unripe) variety	0.05 ± 0.03 (0.00 – 0.09) 0.05	0.17 ± 0.15 (0.00 – 0.45) 0.13	0.21 ± 0.18 (0.00 – 0.54) 0.19	0.28 ± 0.18 (0.00 – 0.53) 0.30	0.94 ± 0.87 (0.00 – 2.53) 0.73	1.22 ± 1.03 (0.00 – 3.06) 1.08

Table 20 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1](Continued)

English name (Fresh fruits)	Wet basis			Dry basis		
	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)
Mangosteen	0.05 ± 0.05	0.21 ± 0.26	0.25 ± 0.26	0.23 ± 0.26	1.04 ± 1.33	1.27 ± 1.57
	(0.00 – 0.11)	(0.00 – 0.58)	(0.00 – 0.69)	(0.00 – 0.56)	(0.00 – 2.93)	(0.00 – 3.49)
	0.04	0.08	0.12	0.20	0.42	0.63
Orange :						
Clementine	0.04 ± 0.11	0.63 ± 0.48	0.68 ± 0.57	0.35 ± 0.86	5.11 ± 3.90	5.46 ± 4.58
variety	(0.00 – 0.26)	(0.00 – 1.36)	(0.00 – 1.62)	(0.00 – 2.11)	(0.00 – 11.00)	(0.00 – 13.11)
	0.00	0.72	0.72	0.00	5.83	5.83
Sai-nuhm-phung	0.33 ± 0.11	0.48 ± 0.15	0.82 ± 0.23	2.35 ± 0.81	3.44 ± 1.03	5.78 ± 1.60
variety	(0.23 – 0.52)	(0.32 – 0.67)	(0.57 – 1.20)	(1.63 – 3.70)	(2.27 – 4.77)	(4.01 – 8.47)
	0.29	0.45	0.82	2.07	3.19	5.81
Papaya :						
Khak-dahm variety	ND	ND	ND	ND	ND	ND

Table 20 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1](Continued)

English name	Wet basis			Dry basis		
(Fresh fruits)	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)
Pineapple :						
Sri-ra-cha variety	ND	ND	ND	ND	ND	ND
Pomelo :						
Khao-nahm-peung variety	0.28 ± 0.21 (0.09 – 0.56) 0.17	0.52 ± 0.31 (0.17 – 0.94) 0.49	0.80 ± 0.48 (0.26 – 1.50) 0.82	2.35 ± 1.78 (0.80 – 4.75) 1.48	4.42 ± 2.66 (1.41 – 7.96) 4.19	6.76 ± 4.05 (2.20 – 12.70) 6.96
Tongdee variety	0.59 ± 0.53 (0.00 – 1.51) 0.56	1.41 ± 1.16 (0.00 – 3.22) 1.45	2.00 ± 1.53 (0.00 – 3.94) 2.10	5.24 ± 4.68 (0.00 – 13.42) 5.01	12.54 ± 10.28 (0.00 – 28.60) 12.92	17.78 ± 13.63 (0.00 – 35.01) 18.68
Rambutan :						
Rong-rean variety	1.84 ± 1.51 (0.00 – 3.43) 2.27	0.20 ± 0.19 (0.00 – 0.49) 0.18	2.04 ± 1.63 (0.00 – 3.63) 2.60	9.59 ± 7.84 (0.00 – 17.88) 11.85	1.02 ± 0.99 (0.00 – 2.56) 0.95	10.62 ± 8.51 (0.00 – 18.92) 13.56

Table 20 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1](Continued)

English name (Fresh fruits)	Wet basis			Dry basis		
	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)
Rose apple :						
Toon-klow variety	ND	ND	ND	ND	ND	ND
Tub- tim-jun variety	ND	0.01 ± 0.02 (0.00 – 0.04) 0.00	0.01 ± 0.02 (0.00 – 0.04) 0.00	ND	0.10 ± 0.16 (0.00 – 0.39) 0.00	0.10 ± 0.16 (0.00 – 0.39) 0.00
Salacca	ND	ND	ND	ND	ND	ND
Sapodilla	ND	1.50 ± 0.06 (1.43 – 1.62) 1.49	1.50 ± 0.06 (1.43 – 1.62) 1.49	ND	6.13 ± 0.26 (5.85 – 6.62) 6.07	6.13 ± 0.26 (5.85 – 6.62) 6.07

Table 20 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1](Continued)

English name (Fresh fruits)	Wet basis			Dry basis		
	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)
Star fruit	0.03 ± 0.06 (0.00 – 0.15) 0.00	0.29 ± 0.35 (0.00 – 0.90) 0.21	0.32 ± 0.36 (0.00 – 0.90) 0.24	0.31 ± 0.56 (0.00 – 1.39) 0.00	2.65 ± 3.28 (0.00 – 8.32) 1.96	2.95 ± 3.34 (0.00 – 8.32) 2.19
Strawberry	0.40 ± 0.19 (0.24 – 0.76) 0.35	1.75 ± 0.42 (1.39 – 2.46) 1.56	2.15 ± 0.60 (1.71 – 3.22) 1.87	3.84 ± 1.80 (2.34 – 7.27) 3.31	16.75 ± 3.99 (13.33 – 23.53) 14.91	20.59 ± 5.70 (16.34 – 30.79) 17.87
Sugar apple : Nahng variety	ND	ND	ND	ND	ND	ND
Watermelon : Jin-trarah variety (red color)	ND	ND	ND	ND	ND	ND

Table 20 Polyphenol, Tannin, Catechin contents in fresh fruits and fruits in syrup[1](Continued)

English name	Wet basis			Dry basis		
(Fresh fruits)	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)	IP 5 (mg/100 g)	IP 6 (mg/100 g)	Phytate (mg/100 g)
Jin-trarah variety (yellow color)	ND	0.21 ± 0.39 (0.00 – 0.97) 0.00	0.21 ± 0.39 (0.00 – 0.97) 0.00	ND	2.41 ± 4.58 (0.00 – 11.44) 0.04	2.41 ± 4.58 (0.00 – 11.44) 0.04

[1]Data were reported as a mean ± SD of duplicate analysis, range (min-max) and medium (n=6 sample/each kind of fruit). With exception * n=5, **n=2.

ND = Not detected

Table 21 phytate content of fresh fruits and fruits in syrup[1]

English name (Fresh fruits)	Variety	One portion (g)[2]	IP 5 (mg/portion of weight)	IP 6 (mg/portion of weight)	Phytate (mg/portion of weight)	N
Apple	Fuji	102	0.02	1.53	1.55	6
	Granny Smith	102	0.00	1.69	1.69	6
Banana (ripe)	Hawm	53	0.04	0.03	0.07	6
	Kai	48	0.05	0.16	0.21	6
	Nahm-wah	53	0.08	0.19	0.27	6
Chinese pear	Hawm	136	0.02	1.03	1.05	6
	Namphung	135	0.00	1.23	1.23	6
Dragon fruit	Vietnam	120	1.22	6.01	7.22	6
Durain	Chanee	58	ND	ND	ND	6
	Mawntong	50	ND	ND	ND	6
Grape	Green	93	0.12	0.46	0.58	6
Guava	Pan-seetong	123	0.34	2.67	3.01	6
Jack fruit		61	0.06	0.68	0.74	6

Table 21 phytate content of fresh fruits and fruits in syrup[1] (mg/portion of weight) (Continued)

English name (Fresh fruits)	Variety	One portion (g)[2]	IP 5 (mg/portion of weight)	IP 6 (mg/portion of weight)	Phytate (mg/portion of weight)	N
Longan	Kalokbew	86	0.09	0.01	0.10	6
Longkong		94	0.63	2.40	3.03	6
Lychee	Hohnghooway*	98	1.12	0.70	1.81	5
	Jackkrapat	78	1.50	1.85	3.35	6
Mango	Kheosawoei(unripe)	75	0.04	0.15	0.19	6
	Nahmdawgmai (ripe)	79	0.02	0.07	0.09	6
	Rad (unripe)	76	0.04	0.13	0.16	6
Mangosteen		77	0.04	0.16	0.19	6
Orange	Clementine	101	0.04	0.64	0.68	6
	Sai-nuhm-phung	122	0.40	0.59	1.00	6
Papaya	Khak-dahm	130	ND	ND	ND	6
Pineapple	Sri-ra-cha	101	ND	ND	ND	6

Table 21 phytate content of fresh fruits and fruits in syrup[1] (mg/portion of weight) (Continued)

English name (Fresh fruits)	Variety	One portion (g)[2]	IP 5 (mg/portion of weight)	IP 6 (mg/portion of weight)	Phytate (mg/portion of weight)	N
Pomelo	Khao-nahm-peung	92	0.25	0.48	0.73	6
	Tongdee	125	0.74	1.77	2.50	6
Rambutan	Rong-rean	75	1.38	0.15	1.53	6
Rose apple	Toon-klow	205	ND	ND	ND	6
	Tub- tim-jun	152	0.00	0.03	0.03	6
Salacca		78	ND	ND	ND	6
Sapodilla		69	0.00	1.04	1.04	6
Star fruit		159	0.05	0.45	0.51	6
Strawberry		180	0.72	3.15	3.87	6
Sugar apple	Nahng	57	ND	ND	ND	6

Table 21 phytate content of fresh fruits and fruits in syrup[1] (mg/portion of weight) (Continued)

English name (Fresh fruits)	Variety	One portion (g)[2]	IP 5 (mg/portion of weight)	IP 6 (mg/portion of weight)	Phytate (mg/portion of weight)	N
Watermelon	Jin-trarah variety (red color)	170	ND	ND	ND	6
	Jin-trarah variety (yellow color)	188	0.00	0.39	0.39	6

[1]Data were reported as a mean of duplicate analysis (n=6). With exception * n=5, **n=2

[2] One portion of fresh and canned fruits was calculated by based on 15 gram of carbohydrate that recommended from the food exchange list (68)

ND = Not detected

5.5.1 The molar ratios of Phytate : Iron, Phytate : Zinc and [Calcium] [Phytate] : Zinc

The results of the phytate : iron, phytate : zinc and [Ca][Phytate] : zinc molar ratios from the present study were showed in Table 22. The phytate : iron molar ratios of selected Thai fresh fruits ranged from 0.01 to 2.06 : 1. Rose apple (tub-tim-jun variety) had the lowest molar ratio of phytate : iron, while Lychee (jakkrapat variety) had the highest molar ratio of phytate : iron. The highest molar ratios of phytate:zinc was found in apple (Granny Smith variety) (4.2 :1). The lowest molar ratios of phytate : zinc was found in rose apple (tub-tim-jun variety) (about 0.02 : 1). While the [calcium][phytate] : zinc ranged from 0.01 to 38.96:1. The highest molar ratios of [calcium][phytate] : zinc was found in Pomelo (tongdee variety). The lowest molar ratios of [calcium][phytate] : zinc was found in ripe Banana (Hawm, Kai varieties) and Star fruit. Again based on data analysis of phytate or calculation of molar ratio of phytate with some minerals (iron, zinc and calcium), it revealed that small amount of the molar ratios between phytate and iron, zinc or calcium was obtained for all fruit samples.

Table 22 The molar ratios of Phytate : Iron, Phytate : Zinc and [Calcium][Phytate] : Zinc

English name (Fresh fruits)	Variety	Molar ratios		Molar ratios		Molar ratios	
		Phytate	**Fe**	**Phytate**	**Zn**	**[Ca][Phytate]**	**Zn**
Apple	Fuji	1.09	1	3.35	1	12.71	1
	Granny Smith	0.92	1	4.20	1	20.09	1
Banana (ripe)	Hawm	0.05	1	0.12	1	0.01	1
	Kai	0.15	1	0.26	1	0.01	1
	Nahm-wah	0.10	1	0.29	1	0.04	1
Chinese pear	Hawm	0.28	1	0.90	1	5.22	1
	Namphung	1.02	1	1.38	1	2.50	1
Dragon fruit	Vietnam	2.48	1	3.08	1	3.08	1
Durain	Chanee	0.00	1	0.00	1	0.00	1
	Mawntong	0.00	1	0.00	1	0.00	1
Grape	Green	0.27	1	0.83	1	0.12	1
Guava	Pan-seetong	1.40	1	2.42	1	0.19	1
Jack fruit		0.38	1	0.81	1	8.47	1

Table 22 The molar ratios of Phytate : Iron, Phytate : Zinc and [Calcium][Phytate] : Zinc (Continued)

English name (Fresh fruits)	Variety	Molar ratios		Molar ratios		Molar ratios	
		Phytate	**Fe**	**Phytate**	**Zn**	**[Ca][Phytate]**	**Zn**
Longan	Kalokbew	0.05	1	0.09	1	0.64	1
Longkong		1.44	1	1.39	1	10.97	1
Lychee	Hohnghooway*	0.76	1	1.23	1	2.81	1
	Jackkrapat	2.60	1	3.71	1	8.35	1
Mango	Kheosawoei(unripe)	0.13	1	0.26	1	0.03	1
	Nahmdawgmai (ripe)	0.06	1	0.15	1	0.02	1
	Rad (unripe)	0.14	1	0.30	1	0.06	1
Mangosteen		0.17	1	0.27	1	2.00	1
Orange	Clementine	0.53	1	1.31	1	22.45	1
	Sai-nuhm-phung	0.60	1	1.83	1	0.66	1
Papaya	Khak-dahm	0.00	1	0.00	1	0.00	1
Pineapple	Sri-ra-cha	0.00	1	0.00	1	0.00	1

Table 22 The molar ratios of Phytate : Iron, Phytate : Zinc and [Calcium][Phytate] : Zinc (Continued)

English name (Fresh fruits)	Variety	Molar ratios		Molar ratios		Molar ratios	
		Phytate	**Fe**	**Phytate**	**Zn**	**[Ca][Phytate]**	**Zn**
Pomelo	Khao-nahm-peung	0.57	1	1.42	1	10.96	1
	Tongdee	1.49	1	4.13	1	38.96	1
Rambutan	Rong-rean	1.32	1	1.70	1	13.85	1
Rose apple	Toon-klow	0.00	1	0.00	1	0.00	1
	Tub- tim-jun	0.01	1	0.02	1	0.00	1
Salacca		0.00	1	0.00	1	0.00	1
Sapodilla		0.92	1	1.94	1	28.60	1
Star fruit		0.15	1	0.15	1	0.01	1
Strawberry		0.59	1	1.47	1	17.31	1
Sugar apple	Nahng	0.00	1	0.00	1	0.00	1

Table 22 The molar ratios of Phytate : Iron, Phytate : Zinc and [Calcium][Phytate] : Zinc (Continued)

English name (Fresh fruits)	Variety	**Molar ratios**		**Molar ratios**		**Molar ratios**	
		Phytate	**Fe**	**Phytate**	**Zn**	**[Ca][Phytate]**	**Zn**
Watermelon	Jin-trarah variety (red color)	0.00	1	0.00	1	0.00	1
	Jin-trarah variety (yellow color)	0.05	1	0.27	1	0.11	1

CHAPTER VI
DISCUSSION

6.1 Mineral analysis of 39 fresh fruits and 4 fruits in syrup

It has been known that fruits are important source of vitamins and minerals (70-74). Fruits and vegetables have low energy content, while the nutrient density are very high especially potassium and polyphenol (70-74, 80-82). Recently, many researchers indicated that some components of fruits and vegetables might prevent or linked to decrease risk of non-communicable diseases such as heart diseases, diabetes and some certain cancers (22, 23). Increased consumption of fruits and vegetables may help by replacing foods which are high in calorie density and also high in saturated fats, sugar and salt. Therefore, to promote good health and prevent any chronic diseases, increasing consumption of vegetables and especially fresh fruits should be encouraged. In 2003, WHO recommended that the consumption of fresh fruits and vegetables to be more than 400 g/d can prevent non-communicable disease such as cardiovascular diseases and certain cancers (75). However, during the past decade, eating patterns and lifestyle (19-21) have shifted from a traditional practice to a more westernized one. The consumption of high fats, high sugars, and low fruits and vegetables were observed. This leads to a rising incidence and mortality rate of chronic diseases (19-21).

In this study, mineral compositions of various varieties of Thai fruits were analyzed. The mineral compositions of fruits are influenced by many cultivar of plant such as the production area, cultivar, soil and climate conditions during growing, agricultural practices, use of fertilizers, the state of the fruits maturity at harvest, storage conditions and transportation conditions before reaching to consumers (76, 78, 87). It is scientifically accepted that the mineral compositions of fruits is a distorted reflection of the mineral composition of the soil and environment in which the plants grow. The macro- and micro- elements were determined from 39 fresh fruits and 4 fruits in syrup were showed in Table 12-14 and 15-17. The highest content of analyzed elements in the entire samples was potassium (K). Epidemiological and

clinical studies have strongly suggested that an increase in K intake can decrease blood pressure (38, 39). This was supported by the conclusion of meta-analysis of clinical trials that low potassium intake may play an important role in the genesis of high blood pressure (39). However, in the end-stage of chronic renal failure, patients should be avoiding food with high potassium. If the level of potassium in blood is higher than 6.5 mmol/l, it affects the muscle and eventually causes abnormal function that may contribute to malfunction of the heart muscle and death in the patients (32, 33). In this study, the result of potassium content in fresh fruits and fruits in syrup ranged from 136.88 to 1933.50 mg/100 g dry wt or 28.30 to 405.60 mg/100 g edible portion. Some values were similar and some were varied to those reported in nutritive values of Thai food composition table, INMU 1999, and the study of Kongkachuichai R, 1990 see in table 23 (69, 77). The excellent source of potassium was found in ripe papaya (Khak-dham variety, 1933.50 mg/100 g dry wt or 198.64 mg/100 g edible portion). In term of milligram per 100 g edible portion, ripe banana (Kai and Hawm varieties) and durian (Chanee variety) were rich sources of potassium (ranged from 309.75 to 405.60 mg/100 g edible portion). The potassium value of ripe papaya (Khak-dham variety) in each market of this study (range from 136.54 - 364.64 mg/100 g edible portion) was close to the value from Thai food composition table, INMU, 1999, (230 mg/100 g edible portion) and other publications by Wall MM (2006) (153.9 mg/100 g edible portion) and Sanchez-Castillo et al (1998) (194 mg/100 g edible portion) but higher than the study of Leterme P et al (2005) which found that the K in ripe papaya contained by about 85 mg/100 g edible portion (70-72). In addition, potassium content of ripe banana in present study was similar to the values reported by Wall M.M. (2006) who found that potassium content of banana was 330.6 mg/100 g edible portion, (table 23). In contract, the potassium content in banana obtained from this study was in disagreement to the potassium content reported by Harrison A et al. (2001) who found that potassium content of banana was 509 mg/100 g edible portion (74). In addition, the potassium contents of longan, lychee and rambutan of this study were lower than those reported by Wall MM. in 2006 (73). However, Leterme P et al. (2005) reported the potassium contents in guava, mango, sugar apple and star fruit (332, 176, 368 and 102 mg/100 g edible portion, respectively) which were higher than those fruits of in this study, while the contents in pineapple (39 mg/100 g edible

portion) and ripe papaya (85 mg/100 g edible portion) are lower (71). Comparison of the potassium contents in watermelon between Thai food composition table, INMU, 1999 with the value of present study found that the potassium in watermelon obtained in this study was higher (111.35 and 119.78 mg/100g edible portion) than that obtained from Thai food composition table, INMU, 1999 (78 mg/100g edible portion). There are differences between the value of K in ripe papaya, longan, lychee, rambutan, guava, mango, sugar apple, star fruit and watermelon which obtained in the present study and other publications such as Leterme P (2005), Wall M.M. (2006) (with exception of K value in ripe papaya) and Harrison A et al. (2001) (71-74). The content of potassium in strawberry in this study was lower than that of Hakala M, et al (2003) (209 mg/100g edible portion) (78). Some data analyses obtained in this study were more or less similar to the potassium values reported in other previous publications. The main causes of differences in K content might be due to the different in variety, sampling method, sample preparing and methodology, and in various conditions as addressed above (76, 78, 87). Unfortunately, no further information of potassium contents in other fruits and fruit in syrup is available in other previous publications.

Recently, the Recommended Daily Intake for Thais (Thai RDI) in 1998 recommended that potassium requirement for adult people should be around 3,500 mg/day (34). The consumption of dragon fruit (Vietnam variety) which have the highest potassium content for one portion or equal to 120 g edible portion would meet around 9% of the Thai RDI.

Sodium content of fresh fruits and fruits in syrup ranged from 2.83 to 69.80 mg/100 g dry wt or 0.59 to 16.32 mg/100 g edible portion. Among all fruit samples, pomelo (Tongdee variety) was the excellent source of sodium (69.80 mg/100 g dry wt or 7.86 mg/100 g edible portion). Sapodilla was a good source of sodium (16.32 mg/100 g edible portion or 66.69 mg/100g dry wt). The values of sodium in fresh fruits (mg/100g edible portion) such as apple (Fuji; without peeled and Granny Smith; with peeled varieties), ripe banana (Hawm and Kai, varieties), chinese pear (Hawm; without peeled, Namphung; with peeled varieties), durian (Chanee and Mawntong varieties), grape (Green variety), guava (Pun-seetong variety), jackfruit, lychee (Hohnghooway and Jackkrapat varieties), unripe mango (Kheosawoei and Rad, varieties), orange (Clementine and Sai-nuhm-phung, varieties), ripe papaya (Khak-

dahm variety), pineapple (Sriracha variety), rose apple (Toon-klow variety), sapodilla, sugar apple (Nahng variety) and watermenlon (Jin-trarah yellow color variety) and all fruit in syrup were lower than those obtained from Thai food composition table, INMU, 1999, while ripe banana (Nahm-wah variety), ripe mango (Nahmdawgmai variety), rambutan (Rong-rean variety), and watermelon (Jin-trarah variety, red color) were in agreement with the value obtained from Thai food composition table, INMU, 1999 (table 23) (69). However, the data of sodium which reported in Thai food composition table, INMU, 1999 were not complete. Comparing the result of sodium in this study with those from the study of Kongkachuichai R, 1990 (77), it was found that sodium contents of durian (Mawntong variety), grape (Green variety), lychee (Jackkrapat variety), unripe mango (Kheosawoei variety), orange (Clementine variety), ripe papaya (Khak-dahm variety) and sapodilla in this study were lower than the values in the study of Kongkachuichai R (1990) while sodium content of longan (Kalokbew variety) in this study was higher than the value in the study of Kongkachuichai R, 1990. Moreover, sodium contents of guava, mango (ripe; Nahmdawgmai variety, unripe; Rad variety), longan (Kalokbew variety), pineapple (Sriracha variety) and star fruit in this study were similar to those in the same varieties in previous studies (70, 71, 73). The study of Wall M.M, 2006 (72, 73) found that sodium contents of banana, papaya and rambutan (16.55, 9.8 and 6.1 mg/100 g edible portion, respectively) were higher than the values in this study (4.14-6.70, 2.85 and 3.16 mg/100 g edible portion, respectively). However, sodium content of ripe papaya in this study (2.85 mg/100 g edible portion) was similar to that of the study of Sanchez-Castillo et al (1998) (3 mg/100 g edible portion) (70) but lower than a value from the study of Wall M.M (2006) and Leterme P, et al (2005) (9.8 and 7 mg/100 g edible portion) (table 23).

Recently, the recommendation of daily intake for Thais (Thai RDI) in 1998 recommends that sodium requirement for adult people should be around 2400 mg/day (34). However, data of present study indicated that all fresh or syrup fruits were not good sources of sodium. Therefore, the consumption of fresh fruits and fruits in syrup per one portion would meet 0 to 0.5% of the Thai RDI. The highest source of sodium in this study was sapodilla.

Calcium content in the present study ranged from 7.17 to 138.91 mg/100 g dry wt or 1.17 to 22.09 mg/100 g edible portion. The consideration of calcium value in all samples of data showed that orange (Clementine variety) was the excellent source of calcium content when compared to all fruit samples (138.91 mg/100 g dry wt or 17.18 mg/100 g edible portion). Most kinds of fruits had the calcium values lower than those reported in nutritive values of Thai food composition table, INMU, 1999 (69), while calcium contents of longan (Kalokbew variety), and sapodilla were closely to the nutritive values of Thai food composition table, INMU (1999). In addition, comparing these results with those obtained by Wall M.M. (2006) (72), the mean concentrations of calcium in banana and papaya (6.39, 16.6 mg/100 g edible portion, respectively) were higher than those of ripe banana (2.69 mg/100g edible portion of Hawm variety, 2.03 mg/100g edible portion of Kai variety and 5.63 mg/100g edible portion of Nahm-wah variety) and ripe papaya (8.06 mg/100g edible portion of Kahm-dahm variety) in this study while the study of Hardisson A, et al (2001) (74) demonstrated that calcium content in banana was 18.8 mg/100 g edible portion. However, the calcium values of longan (Biew Kiew variety) and rambutan (Rong-rean variety) (6.6 and 8.2 mg/100 g edible portion, respectively) that were published by Wall M.M, (2006) were closed to those of this study. The calcium content of ripe papaya was lower (8.06 mg/100 g edible portion) than that of the previous publication by Leterme P, et al (2005) and by Sanchez-Castillo, et al (1998) who reported that calcium in papaya was around 16-16.6 mg/100 g edible portion (70, 71), see in table 23. In pineapple, the calcium concentration (10.15 mg/100 g edible portion) was closed to that reported by Sanchez-Castillo, et al (1998) who found that calcium in pineapple was around 11 mg/100 g edible portion (70). While calcium content of pineapple in this study was two times lower than that reported from Leterme P, et al (2005) (21 mg/100 g edible portion). The value of calcium in strawberry in this study was lower than that of Hakala M, et al (2003) (18.9 mg/100g edible portion) (78) (table 23).

The Thai RDI for calcium is 800 mg/day for adults (34). Data of present study indicated that fruits were not good source of calcium. Therefore, the consumption of Thai fruit one portion would meet only 0 - 3% requirement of the Thai RDI. The highest sources of calcium in this study were found in strawberry.

For magnesium, the value ranged from 14.71 to 150.45 mg/100g dry wt or 3.08 to 25.21 mg/100 g edible portion. Comparison among the magnesium content between various fresh fruits varieties and fruits in syrup showed that dragon fruit (Vietnam variety) was a great source of magnesium (150.45 mg/100 g dry wt or 22.65 mg/100 g edible portion). When the values were expressed to milligram per 100 g edible portion, the results showed that all ripe bananas (Hawm, Kai and Nahm-wah varieties), dragon fruit (Vietnam variety) and sugar apple (Nahng variety) were rich sources of magnesium (ranged from 21.02 to 25.21 mg/100 g edible portion). For magnesium, no information of magnesium value of Thai fruits is available in Thai food composition table, INMU (1999) (69). However, some values of magnesium in this study were lower than the results of Kongkachuichai R. (77) who determined the macro-element in Thai vegetables and fruits except grape (Green variety), jackfruit, lychee (Jackkrapat variety), mango (unripe:Kheosawoei, ripe:Nahmdawgmai and unripe:Rad variety), ripe papaya (Khak-dahm variety), pineapple (Sriracha variety). When comparing results in this study with other studies, it was found that magnesium content in pineapple (ranged from 4.62-14.84 mg/100 g edible portion) was in agreement with the publication of Leterme P, et al (2005) and Sanchez-Castillo, et al (1998) (9 and 13 mg/100 g edible portion, see in table 23 (70, 71). The study of Wall M.M, (2006) (72, 73) showed that magnesium content in banana, longan (Biew Kiew and Sri chompoo variety), papaya and rambutan were 35.1, 12.4, 14.2, 24.8 and 15 mg of magnesium/100 g edible portion, respectively. Those values were higher than the value in this present study. In addition, magnesium content in ripe papaya of this study was about 3.04 to 9.52 mg/100 g edible portion which is somewhat nearly the values observed by Leterme P., et al (2005) and Sanchez-Castillo, et al (1998) (10 and 8 mg/100 g edible portion, respectively) (70, 71) but lower than those reported by Wall M.M, (2006) (24.8 mg/100g edible portion) (72). The magnesium content of strawberry in this study was lower than the value from Hakala M., et al (2003) (16.1 mg/100g edible portion) (78). The value of magnesium of sugar apple and star fruit in this study were also two times lower than those reported by Leterme P., et al (2005) (47 and 13 mg/100 g edible portion, respectively), while that of guava was also 3 times lower (15 mg/100 g edible portion), (table 23) (71).

The Daily Intake for Thais (Thai RDI) for magnesium is 350 mg/day for adults (34). The greatest source of magnesium in this study was dragon fruit (Vietnam variety), (table 25).Therefore, the consumption of dragon fruit (Vietnam variety) one portion or 120 g would meet 8 % requirement for Thai RDI.

However, among the macro-mineral contents in the fruit samples both in fresh and in syrup, it was found that potassium was the greatest (28.30 – 405.60 mg K/100g edible portion) and low in sodium (0.59 – 16.32 mg Na/100g edible portion, see in table 13. These findings were in agreement with the Leterme P., et al (2006) and Kongkachuichai R. (1990) indicated that macro-element content of tropical fruit and Thai fruits are generally high in potassium and low - very low in sodium (71, 77). In this study found that the consumption of dragon fruit which had the highest potassium content for one portion or equal to 120 g edible portion would meet around 9% requirement of the Thai RDI (34). The Thai RDI for magnesium (Mg) is 350 mg/day for Thai adults, one portion or 120 g of dragon fruit (Vietnam variety) would provide 8% of The Thai RDI for Mg. Strawberry was the highest source of calcium content (3% of Thai RDI) considered by % of Thai RDI.

Table 23 Comparison of the results obtained in this study with other publications

English name	Scientific name	References	Macro-minerals (mg/100 g edible portion)[1]			
			Sodium	Potassium	Calcium	Magnesium
Apple	*Pyrus malus, Borkh.*	Present study				
	Fuji variety (not peeled)		1.78	29.25	3.79	3.55
	Granny Smith variety (peeled)		2.43	29.45	4.79	4.12
	Pyrus malus, Borkh.	Thai food composition table, INMU, 1999	64	122	12	-
Banana	*Musa sp.* (Hawm)	Present study	4.14	346.98	2.69	21.45
	Musa sapientum;Linn (Kai)		6.70	309.75	2.03	22.53
	Musa sapientum. (Nahmwah)		4.74	203.78	5.63	25.21
	Musa sp. (Hawm)	Thai food composition table, INMU, 1999	21	323	5	-
	Musa sapientum;Linn (Kai)		10	328	6	-
	Musa sapientum (Nahmwah)		5	248	10	-

Table 23 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Macro-minerals (mg/100 g edible portion)[1]			
			Sodium	Potassium	Calcium	Magnesium
	Musa nana (Hawm)	Kongkachuichai R., 1990	8	301	-	62
	Musa sapientum (Kai)		4	248	-	34
	Musa spp. (Nahmwah)		5	248	-	59
	Musa sp.	Wall M.M. 2006	16.55	330.6	6.39	35.1
	Musa acuminata	Hardisson A et al. 2001	11.7	509	18.8	37.7
Chinese pear	*Pyrus communis*					
	Hawm variety	Present study	4.66	40.54	5.80	7.12
	Namphung variety		3.84	51.15	1.81	5.96
	Pyrus communis	Thai food composition table, INMU, 1999	24	179	7	-
Dragon fruit	*Hylocereus spp.*	Present study	3.98	270.56	2.71	22.65
	Vietnam variety	Thai food composition table, INMU, 1999	-	-	9	-

Table 23 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Macro-minerals (mg/100 g edible portion)[1]			
			Sodium	Potassium	Calcium	Magnesium
Durian	*Durio spp.*	Present study				
	Chanee variety		4.20	405.60	4.19	16.36
	Mawntong variety		2.03	291.82	4.03	19.90
	Chanee variety	Thai food composition	29	422	7	-
	Mawntong variety	table, INMU, 1999	6	436	29	-
	Durio zibethinus	Kongkachuichai R., 1990				
	Chanee variety		3	442	-	19
	Mawntong		3	437	-	23
Grape	*Vitis vinifera, L.*	Present study	6.39	124.68	6.00	5.39
		Thai food composition table, INMU, 1999	12	151	8	-
		Kongkachuichai R., 1990	12	151	-	6
Guava	*Psidium guajava*	Present study	5.75	209.59	3.19	5.75
		Thai food composition table, INMU, 1999	15	164	10	-

Table 23 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Macro-minerals (mg/100 g edible portion) [1]			
			Sodium	Potassium	Calcium	Magnesium
		Kongkachuichai R., 1990	4	126	-	10
		Leterme P. et al 2005	6	349	25	15
Jackfruit	*Artocapus heterophylla*	Present study	4.63	206.93	10.39	18.90
		Thai food composition table, INMU, 1999	43	431	24	-
		Kongkachuichai R., 1990	3	215	-	19
Longan	*Euphoria longana, Lamk.*	Present study	10.96	105.15	6.78	8.41
		Thai food composition table, INMU, 1999	-	-	6	-
	Euphoria longana	Kongkachuichai R., 1990	6	242	-	19
	Dimocarpus longan	Wall M.M. 2006				
	Biew Kiew variety		9.0	318.5	6.6	12.4
	Sri chompoo variety		14.1	334.4	9.6	14.2

Table 23 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Macro-minerals (mg/100 g edible portion)[1]			
			Sodium	Potassium	Calcium	Magnesium
Longkong	*Lansium domesticum*	Present study	2.85	191.87	7.90	12.29
	Corr	Thai food composition table, INMU, 1999	-	-	5	-
Lychee	*Litchi chinensis, Sonn.*	Present study	3.44	131.36	2.29	10.37
	Hohnghooway variety					
	Jackkrapat variety		2.56	165.27	2.23	9.17
	Litchi chinensis, Sonn.	Thai food composition				
	Hohnghooway variety	table, INMU, 1999	4	177	3	-
	Jackkrapat variety		7	123	3	-
	Litchi sinensis	Kongkachuichai R., 1990				
	Hohnghooway variety		4	177	-	13
	Jackkrapat variety		7	123	-	10
Mango	*Mangifera indica*	Present study				
	Kheosawoei variety		0.59	89.88	5.23	8.64
	Nahmdawgmai variety		2.64	81.36	4.52	8.88

Table 23 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Macro-minerals (mg/100 g edible portion)[1]			
			Sodium	Potassium	Calcium	Magnesium
	Rad variety		3.48	104.83	8.06	7.43
	Mangifera indica Kheosawoei variety	Thai food composition table, INMU, 1999	3	142	6	-
	Nahmdawgmai variety		3	144	6	-
	Rad variety		76	138	20	-
	Mangifera indica	Kongkachuichai R., 1990				
	Kheosawoei variety		3	142	-	10
	Nahmdawgmai variety		3	144	-	9
	Rad variety		2	118	-	8
	Mangifera indica L.	Leterme P. et al 2005	4	246	76	30
	Mangifera indica L.	Sanchez-Castillo et al 1998	5	87	11	5
Mangosteen	*Garcinia mangostana*	Present study	2.00	31.55	7.33	12.06
		Thai food composition table, INMU, 1999	-	-	9	-

Table 23 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Macro-minerals (mg/100 g edible portion)[1]			
			Sodium	Potassium	Calcium	Magnesium
Orange	*Citrus sinesis Osb.*	Present study				
	Clementine variety		1.96	83.65	17.18	8.57
	Sainuhmphung variety		5.37	228.92	14.39	7.09
	Citrus sinesis Osb.	Thai food composition				
	Clementine variety	table, INMU, 1999	5	145	26	-
	Sainuhmphung variety		33	162	29	-
	Citrus sinesis	Kongkachuichai R., 1990				
	Clementine variety		5	133	-	13
	Sainuhmphung variety		6	142	-	13
Papaya	*Carica papaya, Linn.*	Present study	2.85	198.64	8.06	7.13
		Thai food composition table, INMU, 1999	24	230	15	-
	Carica papaya	Kongkachuichai R., 1990	11	142	-	8
		Wall M.M. 2006	9.8	153.9	16.6	24.8

Table 23 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Macro-minerals (mg/100 g edible portion) [1]			
			Sodium	Potassium	Calcium	Magnesium
	Carica papaya, L.	Leterme P. et al 2005	7	85	16	10
		Sanchez-Castillo et al 1998	3	194	16	8
Pineapple	*Ananas comosus, Merr.*	Present study	3.72	61.05	10.15	9.68
		Thai food composition table, INMU, 1999	5	119	11	-
	Ananas comosus	Kongkachuichai R., 1990	5	119	-	10
	Ananas comosus,(L.) Merr.	Leterme P. et al 2005	1	39	21	9
	Ananas comosus, L.	Sanchez-Castillo et al 1998	5	89	11	13
Pomelo	*Citrus maxima, Merr.*	Present study				
	Khaonahmpeung variety		7.59	70.48	7.72	4.78
	Tongdee variety		7.86	91.52	9.44	6.03
	Citrus maxima, Merr.	Thai food composition table, INMU, 1999	-	-	15	-

Table 23 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Macro-minerals (mg/100 g edible portion)[1]			
			Sodium	Potassium	Calcium	Magnesium
Rambutan	*Nephelium lappaceum, Linn.*	Present study	3.16	77.52	8.13	9.86
		Thai food composition table, INMU, 1999	3	131	20	-
	Nephelium lappaceum	Kongkachuichai R., 1990	3	131	-	23
		Wall M.M. 2006	6.1	181.8	8.2	15.0
Rose apple	*Syzygium samarangense* Toon-klow variety	Present study	4.23	61.46	2.02	6.19
	Tup- tim-jun variety		5.82	106.05	1.17	6.60
	Syzygium samarangense Toon-klow variety	Thai food composition table, INMU, 1999	66	107	5	-
	Tub- tim-jun variety		-	-	5	-

Table 23 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Macro-minerals (mg/100 g edible portion) [1]			
			Sodium	Potassium	Calcium	Magnesium
Salacca	*Salacca sp.*	Present study	5.68	114.55	3.37	8.35
		Thai food composition table, INMU, 1999	-	-	8	-
Sapodilla	*Achras sapota, L.*	Present study	16.32	128.11	14.74	9.60
		Thai food composition table, INMU, 1999	22	157	15	-
		Kongkachuichai R., 1990	20	181	-	15
Star fruit	*Averrhoa carambola*	Present study	2.95	74.12	1.56	6.89
		Thai food composition table, INMU, 1999	-	-	9	-
	Averrhoa carambola L.	Leterme P. et al 2005	3	102	10	13
Strawberry	*Fragaria spp.*	Present study	3.33	131.96	11.75	10.31
		Thai food composition table, INMU, 1999	-	-	-	-
		Hakala M. et al, 2003	-	209	18.9	16.1

Table 23 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Macro-minerals (mg/100 g edible portion)[1]			
			Sodium	Potassium	Calcium	Magnesium
Sugar apple	*Auona sguamosa*	Present study	0.78	213.52	15.33	21.02
		Thai food composition table, INMU, 1999	7	224	25	-
		Leterme P. et al 2005	14	460	58	47
Watermelon	*Citruluss vulgalis, Schrad.*	Present study				
	Jin-trarah variety (red color)		5.06	119.78	6.69	8.47
	Jin-trarah variety (yellow color)		3.11	111.35	8.27	7.57
	Citruluss vulgalis, Schrad.	Thai food composition table, INMU, 1999	6	78	10	-
	Citrulus vulgaris	Kongkachuichai R., 1990	6	78	-	10

Table 23 Comparison of the results obtained in this study with other publications (Continued)

English name	Reference	Macro-minerals (mg/100 g edible portion) [1]			
		Sodium	Potassium	Calcium	Magnesium
Fruit salad	Present study	3.77	79.98	10.22	7.09
	Thai food composition table, INMU, 1999	7	-	14	-
Longan in syrup	Present study	2.09	54.50	22.09	3.08
	Thai food composition table, INMU, 1999	6	-	10	-
Lychee in syrup	Present study	8.90	76.09	8.55	4.67
	Thai food composition table, INMU, 1999	14	-	9	-
Rambutan in syrup	Present study	6.95	28.30	20.15	4.04
	Thai food composition table, INMU, 1999	10	-	19	-

[1]Data were reported as a means

In all fruit varieties, the wide variation of iron content ranged from 0.54 to 3.01 mg/100 g dry wt or 0.08 to 0.33 mg/100 g edible portion. The greatest amount of iron was found in durian (Chanee variety; 0.32 mg/100 g edible portion) strawberry (0.32 mg/100g edible portion) and ripe banana (Nahm-wah variety; 0.33 mg/100 g edible portion). These values were lower than those in the Thai food composition table, INMU, 1999 (69) except for longan (Kalokbew variety). In addition, iron content in ripe banana in this study was closed to iron content (0.31 mg/100 g edible portion) of banana which published by Hardisson et al (2001) (74) but lower than iron content in banana of Wall M.M. (2006) (72). Leterme P et al, 2005 (71) demonstrated that iron content in guava, mango, papaya, star fruit and sugar apple were 0.89, 0.42, 0.37, 1.72, 1.34 mg/100 g edible portion, respectively. These values were higher than iron content in the same fruits in this study. In addition, the study of Sanchez-Castillo, et al (1998) (70) showed that the concentration of iron in mango, papaya and pineapple (0.4, 0.3 and 0.5 mg/100 g edible portion, respectively) were higher than those in this study. In addition, iron content of strawberry in this study was 0.32 mg/100g edible portion. This value was similar to iron content of strawberry in the study of Hakala M, et al (2003) (78), (table 24).

The recommendation of dietary intake for Thais (Thai RDI) in 1998 suggested that the requirement of Thai adult people should be around 15 mg/d for iron (34). Fruits are commonly known that they are not good source of micro-elements particularly iron, zinc and copper which confirmed by the results in this study. Therefore, the consumption of fresh fruits and fruits in syrup per one portion would meet only 1-4% of Thai RDI. The highest source of iron calculated per portion was strawberry (4% of Thai RDI).

The present study showed that the range of copper content was 0.18 to 1.59 mg/100 g dry wt or 0.04 to 0.27 mg/100 g edible portion. Lychee (Hohnghooway variety) and grape (Green variety) were the greatest sources of copper in fresh and canned fruits (1.04 and 1.59 mg/100 g dry wt), while longkong and durian (Chanee variety) were the greatest sources of copper when the unit was expressed to per 100 g edible portion (0.24 and 0.27 mg/100 g edible portion). The consideration of copper content in the Thai food composition table, INMU, (1999) (69) showed that the copper content in fresh and canned fruits were lower than the copper content in this study.

The data of copper in Thai food composition table are not complete. From the research of Wall M.M. (2006) (72, 73) showed that copper content in banana, longan (Biew Kiew and Sri chompoo varieties), papaya and rambutan were 0.26, 0.29, 0.23, 0.08 and 0.19 mg/100 g edible portion, respectively. Those values were higher than the content of copper in this study except the copper content in ripe papaya. However, the copper value of ripe papaya in this study (0.08-0.15 mg/100 g edible portion) were higher than that of ripe papaya in the study of Leterma P et al, 2005 (0.01 mg/100 g edible portion) (71) and Sanchez-Castillo et al, 1998 (0.07 mg/100 g edible portion) (70). The value of copper in strawberry in this study (0.16 mg/100g edible portion) was higher than that in the study of Hakala M., et al (2003) (0.06 mg/100 g edible portion) (78) (Table 24).

The recommendation from dietary reference intake for Thais (Thai RDI) in 1998 suggested that Thai adult people should consume copper around 2 mg/day. This value will meet the requirement of human body (34). Eating one portion of these fruits [98g for Lychee (Hohnghooway variety) and 93 g for Grape (green variety)] will meet 10 and 13% of the Thai RDI, respectively.

The values of zinc content ranged from 0.28 to 1.97 mg/100 g dry wt or 0.04 to 0.28 mg/100 g edible portion. The rich source of zinc were found in longkong, dragon fruit (Vietnam variety), strawberry and star fruit (1.22 to 1.97 mg/100 g dry wt), while the rich source of zinc in a unit of per 100 g edible portion were found in jackfruit, durian both in Chanee and Mawntong varieties and grape (Green variety) (0.20 to 0.28 mg/100 g edible portion). The data of zinc in Thai food composition table, INMU (1999) (69) were not complete. However, the Thai food composition table, INMU (1999) showed that zinc content of some fruits was similar and some were varied from those of this study (69). Zinc content of mango in this study was similar to that in the study of Sanchez-Castillo (1998) (0.09 mg/100 g edible portion) (70) and Leterme P., et al (2005) (0.13 mg/100 g edible portion) (71). The report of Wall M.M. (2006) (72, 73) showed that the values of zinc in banana, longan (Biew Kiew and Sri chompoo varieties), papaya and rambutan (0.31, 0.27, 0.28, 0.08 and 0.22 mg/100 g edible portion) were higher than those of the same fruit varieties in this study. Additional, Hakala M et al, 2003 (78) who analyzed mineral content in strawberry found that zinc

content of strawberry was 0.12 mg/100 g edible portion. This value was higher than the zinc content in this study.

The recommendation from dietary reference intake for Thais (Thai RDI) in 1998 suggested that Thai adult people should consume zinc around 15 mg/day, this value will meet requirement of human function (34). The consumption of fresh fruits and fruits in syrup per one portion would meet 0 - 2% of the Thai DRI. The highest values (2% of Thai RDI) were found in star fruit and strawberry.

The main causes of some different on the macro and micro-mineral in this study with other publications, even in Thai food composition table, INMU, 1999, may be due to the production area, cultivar, soil and climate conditions during the growing, agricultural practices, the state of the fruits maturity at harvest, different in method for sampling of fruit sample, preparation and analysis, and transportation conditions before reaching consumers (76, 78, 87), (table 23, 24). When considering calcium content of fruit in syrup and the same kinds of fresh fruits, calcium contents of fruits in syrup are higher than that of the same kinds of fresh fruits (longan, lychee and rambutan). The cause of difference may be due to the manufacturing process of fruit in syrup. This process usually adds Calcium chloride ($CaCl_2$) in water for soaking fruits in order to firm them. This cause is making the difference of the calcium content in those fruits. Considering on the content of macro-micro elements in present study showed that all fresh fruits and fruits in syrup are excellence sources of K especially in durian (Chanee variety) and low in the amount of sodium (Na), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn) and copper(Cu). The calculation on the unit of portion and compared with Thai RDI, the good source of mineral in present study, except sodium which ranged from 10-19% of Thai RDI. In present study found that some fresh fruits are good source of Thai RDI for potassium especially dragon fruit (9%) and copper especially in lychee (Hohnghooway variety) and grape (Green variety) supplied about 10-13% requirement for copper. Thus, lychee and grape were considered as good sources of Cu. All fresh fruits and fruits in syrup are low-very low in amount of sodium (Na), calcium (Ca), magnesium (Mg), iron (Fe) and zinc (Zn).

Table 24 Comparison of the results obtained in this study with other publications

English name	Scientific name	Reference	Micro-minerals (mg/100 g edible portion) [1]		
			Iron	Copper	Zinc
Apple	*Pyrus malus, Borkh.*				
	Fuji variety (not peeled)	Present study	0.12	0.05	0.06
	Granny Smith variety (peeled)	Present study	0.16	0.04	0.06
	Pyrus malus, Borkh.	Thai food composition table, INMU, 1999	0.5	-	-
Banana	*Musa sp.* (Hawm)	Present study	0.24	0.12	0.11
	Musa sapientum;Linn (Kai)		0.26	0.17	0.14
	Musa sapientum. (Nahmwah)		0.33	0.14	0.10
	Musa sp. (Hawm)	Thai food composition table, INMU, 1999	0.6	0.05	0.1
	Musa sapientum;Linn (Kai)		0.6	0.04	0.1
	Musa sapientum (Nahmwah)		0.6	0.05	0.1
	Musa sp.	Wall M.M. 2006	0.78	0.26	0.31
	Musa acuminata	Hardisson A et al. 2001	0.31	0.13	0.17

Table 24 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Micro-minerals (mg/100 g edible portion) [1]		
			Iron	Copper	Zinc
Chinese pear	*Pyrus communis*	Present study			
	Hawm variety		0.23	0.09	0.08
	Namphung variety		0.08	0.07	0.07
	Pyrus communis	Thai food composition table, INMU, 1999	1.1	-	-
Dragon fruit	*Hylocereus spp.*	Present study	0.21	0.20	0.06
	Vietnam variety	Thai food composition table, INMU, 1999	-	-	-
Durian	*Durio spp.*				
	Chanee variety	Present study	0.32	0.27	0.22
	Mawntong variety		0.21	0.17	0.21
	Chanee variety	Thai food composition table, INMU, 1999	0.9	0.13	0.2
	Mawntong variety		1.1	0.11	0.2

Table 24 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Micro-minerals (mg/100 g edible portion) [1]		
			Iron	Copper	Zinc
Grape	*Vitis vinifera, L.* Green variety	Present study	0.20	0.08	0.28
		Thai food composition table, INMU, 1999	0.6	0.42	0.1
Guava	*Psidium guajava*	Present study	0.15	0.10	0.09
		Thai food composition table, INMU, 1999	0.5	0.03	0.4
		Leterme P. et al 2005	0.89	0.10	0.20
Jackfruit	*Artocapus heterophylla*	Present study	0.28	0.15	0.20
		Thai food composition table, INMU, 1999	0.6	-	-
Longan	*Euphoria longana, Lamk.*	Present study	0.22	0.14	0.14
		Thai food composition table, INMU, 1999	0.2	0.10	0.1

Table 24 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Micro-minerals (mg/100 g edible portion) [1]		
			Iron	Copper	Zinc
	Dimocarpus longan	Wall M.M. 2006			
	Biew Kiew variety		0.53	0.29	0.27
	Sri chompoo variety		0.55	0.23	0.28
Longkong	*Lansium domesticum Corr*	Present study	0.20	0.24	0.11
		Thai food composition table, INMU, 1999	0.7	0.09	0.2
Lychee	*Litchi chinensis, Sonn.*	Present study	0.22	0.16	0.19
	Hohnghooway variety				
	Jackkrapat variety		0.15	0.12	0.11
	Litchi chinensis, Sonn.	Thai food composition table,			
	Hohnghooway variety	INMU, 1999	0.5	0.09	0.2
	Jackkrapat variety		-	0.09	0.2
Mango	*Mangifera indica*	Present study			
	Kheosawoei variety		0.17	0.09	0.12
	Nahmdawgmai variety		0.15	0.07	0.08

Table 24 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Micro-minerals (mg/100 g edible portion)[1]		
			Iron	Copper	Zinc
	Rad variety		0.13	0.07	0.16
	Mangifera indica	Thai food composition			
	Kheosawoei variety	table, INMU, 1999	0.2	0.06	0.1
	Nahmdawgmai variety		0.3	0.10	0.1
	Rad variety		0.6	0.06	0.1
	Mangifera indica L.	Leterme P. et al 2005	0.42	0.12	0.13
	Mangifera indica L.	Sanchez-Castillo et al 1998	0.4	0.11	0.09
Mangosteen	*Garcinia mangostana*	Present study	0.13	0.09	0.10
		Thai food composition table, INMU, 1999	0.5	0.11	0.1
Orange	*Citrus sinesis Osb.*	Present study			
	Clementine variety		0.11	0.05	0.07
	Sainuhmphung variety		0.12	0.05	0.05

Table 24 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Micro-minerals (mg/100 g edible portion) [1]		
			Iron	Copper	Zinc
	Citrus sinesis Osb.	Thai food composition			
	Clementine variety	table, INMU, 1999	0.3	0.03	0
	Sainuhmphung variety		0.4	0.07	0.1
Papaya	*Carica papaya, Linn.*	Present study	0.15	0.11	0.04
	Carica papaya	Thai food composition table, INMU, 1999	1.1	0.02	0.1
	Carica papaya, L.	Wall M.M. 2006	0.44	0.08	0.08
		Leterme P. et al 2005	0.37	0.01	0.09
		Sanchez-Castillo et al, 998	0.3	0.07	0.05
Pineapple	*Ananas comosus, Merr*.	Present study	0.18	0.07	0.05
		Thai food composition table, INMU, 1999	0.2	0.04	0.1
	Ananas comosus,(L.) Merr.	Leterme P. et al 2005	0.32	0.01	0.09
	Ananas comosus, L.	Sanchez-Castillo et al 1998	0.5	0.07	0.09

Table 24 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Micro-minerals (mg/100 g edible portion) [1]		
			Iron	Copper	Zinc
Pomelo	*Citrus maxima, Merr.*	Present study			
	Khaonahmpeung variety		0.12	0.06	0.05
	Tongdee variety		0.12	0.05	0.05
	Citrus maxima, Merr.	Thai food composition table, INMU, 1999	0.6	-	-
Rambutan	*Nephelium lappaceum, Linn.*	Present study	0.15	0.13	0.16
		Thai food composition table, INMU, 1999	0.4	0.07	0.1
	Nephelium lappaceum	Wall M.M. 2006	0.47	0.19	0.22
Rose apple	*Syzygium samarangense*	Present study			
	Toon-klow variety		0.13	0.06	0.05
	Tup- tim-jun variety		0.11	0.05	0.04
	Syzygium samarangense	Thai food composition table,			
	Toon-klow variety	INMU, 1999	0.7	-	-
	Tup- tim-jun variety		0.2	-	-

Table 24 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Micro-minerals (mg/100 g edible portion) [1]		
			Iron	Copper	Zinc
Salacca	*Salacca sp.*	Present study	0.20	0.15	0.07
		Thai food composition table, INMU, 1999	0.4	-	-
Sapodilla	*Achras sapota, L.*	Present study	0.14	0.08	0.04
		Thai food composition table, INMU, 1999	0.2	0.03	0.1
Star fruit	*Averrhoa carambola*	Present study	0.18	0.21	0.05
		Thai food composition table, INMU, 1999	0.9	-	-
	Averrhoa carambola L.	Leterme P. et al 2005	1.72	0.19	0.48

Table 24 Comparison of the results obtained in this study with other publications (Continued)

English name	Scientific name	Reference	Micro-minerals (mg/100 g edible portion) [1]		
			Iron	Copper	Zinc
Strawberry	*Fragaria spp*.	Present study	0.32	0.15	0.06
		Thai food composition table, INMU, 1999	-	-	-
		Hakala M. et al, 2003	0.32	0.06	0.12
Sugar apple	*Auona sguamosa*	Present study	0.21	0.16	0.11
		Thai food composition table, INMU, 1999	0.6	-	-
		Leterme P. et al 2005	1.34	0.28	0.53
Watermelon	*Citruluss vulgalis, Schrad.*	Present study			
	Jin-trarah variety (red color)		0.18	0.07	0.07
	Jin-trarah variety (yellow color)		0.15	0.08	0.05
	Citruluss vulgalis, Schrad.	Thai food composition table, INMU, 1999	0.2	0.03	0.1

Table 24 Comparison of the results obtained in this study with other publications (Continued)

English name	Reference	Micro-minerals (mg/100 g edible portion) [1]		
		Iron	Copper	Zinc
Fruit salad	Present study	0.18	0.11	0.06
	Thai food composition table, INMU, 1999	0.2	-	-
Longan in syrup	Present study	0.15	0.07	0.08
	Thai food composition table, INMU, 1999	0.2	-	-
Lychee in syrup	Present study	0.21	0.09	0.10
	Thai food composition table, INMU, 1999	0.2	-	-
Rambutan in syrup	Present study	0.15	0.06	0.09
	Thai food composition table, INMU, 1999	0.2	-	-

[1]Data were reported as a means

Table 25 % of Thai Recommended Daily Intake (Thai RDI) of minerals in fresh fruits and fruits in syrup for Thai adult people

English name (Fresh fruits)	Thai RDI (%)[1,2]						
	Potassium	Sodium	Calcium	Magnesium	Iron	Copper	Zinc
Apple							
Fuji variety(not peeled)	1	0.1	0	1	1	3	1
Granny Smith variety (peeled)	1	0.1	1	1	1	3	0
Banana							
Hawm variety	5	0.1	0	3	1	3	1
Kai variety	4	0.1	0	3	1	4	1
Nahmwah variety	3	0.1	0	4	1	2	1
Chinese pear							
Hawm variety	2	0.3	1	3	2	6	1
Namphung variety	2	0.2	0	2	1	5	1
Dragon fruit Vietnam variety	9	0.2	0	8	1	4	1

Table 25 % of Thai Recommended Daily Intake (Thai RDI) of minerals in fresh fruits and fruits in syrup for Thai adult people (Continued)

English name (Fresh fruits)	Thai RDI (%)[1,2]						
	Potassium	Sodium	Calcium	Magnesium	Iron	Copper	Zinc
Durian							
Chanee variety	7	0.1	0	3	1	6	1
Mawntong variety	4	0	0	3	1	5	1
Grape							
Green variety	3	0.2	1	1	1	13	1
Guava							
Pan-seetong variety	7	0.3	0	2	1	6	1
Jackfruit	4	0.1	1	3	1	6	1
Longan							
Kalokbew variety	3	0.4	1	2	1	6	1
Longkong	5	0.1	1	3	1	6	1

Table 25 % of Thai Recommended Daily Intake (Thai RDI) of minerals in fresh fruits and fruits in syrup for Thai adult people (Continued)

English name (Fresh fruits)	Thai RDI (%)[1,2]						
	Potassium	Sodium	Calcium	Magnesium	Iron	Copper	Zinc
Lychee							
Hohnghooway variety	4	0.1	0	3	1	10	1
Jackkrapat variety	4	0.1	0	2	1	4	1
Mango							
Kheosawoei variety	2	0	0	2	1	4	1
Nahmdawgmai variety	2	0.1	0	2	1	3	1
Rad variety	2	0.1	1	2	1	6	1
Mangosteen	1	0.1	1	3	1	4	1
Orange							
Clementine variety	2	0.1	2	3	1	4	1
Sainuhmphung variety	8	0.3	2	3	1	3	1
Papaya							
Khak-dahm variety	7	0.2	1	3	1	2	1

Table 25 % of Thai Recommended Daily Intake (Thai RDI) of minerals in fresh fruits and fruits in syrup for Thai adult people (Continued)

English name (Fresh fruits)	Thai RDI (%)[1,2]						
	Potassium	Sodium	Calcium	Magnesium	Iron	Copper	Zinc
Pineapple							
Sri-ra-cha variety	2	0.2	1	3	1	2	1
Pomelo							
Khaonahmpeung variety	2	0.3	1	1	1	2	1
Tongdee variety	3	0.4	1	2	1	3	1
Rambutan							
Rong-rean variety	2	0.1	1	2	1	6	1
Rose apple							
Toon-klow variety	4	0.4	0	4	2	5	1
Tub-tim-jun variety	5	0.4	0	3	1	4	1
Salacca	3	0.2	0	2	1	3	1
Sapodilla	3	0.5	1	2	1	2	1

Table 25 % of Thai Recommended Daily Intake (Thai RDI) of minerals in fresh fruits and fruits in syrup for Thai adult people (Continued)

English name (Fresh fruits)	Thai RDI (%)[1,2]						
	Potassium	Sodium	Calcium	Magnesium	Iron	Copper	Zinc
Star fruit	3	0.2	0	3	2	4	2
Strawberry	7	0.2	3	5	4	6	2
Sugar apple Nahng variety	3	0	1	3	1	3	1
Watermelon Jin-trarah variety (red color)	6	0.4	1	4	2	6	1
Jin-trarah variety (yellow color)	6	0.2	2	4	2	5	1

[1] Data of % Thai RDI were calculated from mg/portion and compared with Thai RDI

[2] Thai Recommended Daily Intakes (Thai RDI) are established by the Ministry of Publish Health (1998). Values given are for adult female, males and children 6 or more years of ages.

Table 25 % of Thai Recommended Daily Intake (Thai RDI) of minerals in fresh fruits and fruits in syrup for Thai adult people (Continued)

English name (Fruits in syrup)	Thai RDI (%)[1,2]						
	Potassium	Sodium	Calcium	Magnesium	Iron	Copper	Zinc
Fruit salad	2	0.1	1	2	1	2	1
Longan in syrup	1	0	2	1	1	3	1
Lychee in syrup	2	0.2	1	1	1	4	1
Rambutan in syrup	1	0.2	2	1	1	2	0

[1] Data of % Thai RDI were calculated from mg/portion and compared with Thai RDI

[2] Thai Recommended Daily Intakes (Thai RDI) are established by the Ministry of Publish Health (1998). Values given are for adult female, males and children 6 or more years of ages.

6.2 Polyphenol, tannin and catechin analysis of 39 fresh fruits and 4 fruits in syrup

Polyphenolic compounds are expressed through their action as an inhibitor or an activator for a large variety of mammalian enzyme systems, and as metal chelators and scavenger of free oxygen redicals (79). Total polyphenol content in all fresh and canned fruits were analyzed using the Folin-Ciocauteu reagent. Table 26 showed the comparison of total polyphenol content in this study and the published of total polyphenol. Total polyphenol contents of fresh and canned fruits ranged from 45.44 to 2110.62 mg GAE/100g dry wt and 4.67 to 322.63 mgGAE/100 g edible portion. The study of Cieslik E., et al (2006) showed that polyphenol contents of apple (Gara variety), pink grape, white grape and orange were 964, 683, 793 and 1,461 mg/100g dry mass, respectively (80). These values were higher than the values in this study which found in apple [Fuji (without peeled) variety, 164.09 mgGAE/100g dry basis and Granny Smith (with peeled) variety, 646.04 mgGAE/100 g dry basis], grape (Green variety, 444.03 mgGAE/100 g dry basis), and orange (Clementine variety, 494.66 mgGAE/100 g dry basis and Sai-nuhm-phung variety, 475.75 mgGAE/100 g dry basis). The study of Rababah, et al (2005) (81) showed that the values of total polyphenol in apple and strawberry were 339.2 and 531.7 mg/100g dry wt. These values were lower than the values of total polyphenol of apple and strawberry in this study; apple with peeled (Granny Smith varieties, 646.04 mgGAE/100g dry basis) and strawberry (2,110.62 mgGAE/100g dry basis) except apple without peeled (Fuji variety, 164.09 mgGAE/100g dry basis). In addition, total polyphenol of apple, chinese pear and grape in this study were 24.41 mgGAE/100g edible portion of apple without peeled (Fuji variety), 90.24 mgGAE/100g edible portion of apple with peeled (Granny Smith variety), 29.75 mgGAE/100g edible portion of chinese pear without peeled (Hawm variety), 14.63 mgGAE/100g edible portion of chinese pear with peeled (Nahmphung variety) and 77.48 mgGAE/100g edible portion of grape (Green variety). The data in this study are some similar and variations of variety to those of the publication of Karadenniz F., et al (2005) (82) demonstrated that total polyphenol content in eight varieties of apple, two varieties of grape and three varieties of pear ranged from 54.1 to 133.3 mg/100 g edible portion of apple, 54.8 to 202.5 mg/100 g edible portion of grape and 32.6 to 47.3 mg/100 g edible portion of pear. The

differences of polyphenol content of fruits in this study from those of Cieslik E., et al (2006), Karadenniz F., et al (2005) and Rababah et al (2005) might be due to the difference of the environmental condition, soil, seasonal variation, the state of maturity of plant, different method of sampling and analysis (76, 78, 87).

Data of total polyphenol content per one portion were showed in Table 19. The calculation of total polyphenol content to one portion of each fruits was 6.07 to 397.13 mgGAE/ portion. In this study, the highest sources of polyphenol were sugar apple, star fruit and strawberry (183.90 to 397.13 mgGAE/ portion).

Tannins are polyphenols capable of precipitating proteins from aqueous solution and are widely distributed in plants. They have been reported to be responsible for decreases in feed intake, growth rate, feed efficiency, net metabolizable energy and protein digestibility in experimental animals (83). Tannins are at the centre of interest because of their beneficial physiological property as a scavenger of reactive oxygen intermediates (ROI) (84). Moreover, these tannic acids can behave as both antioxidants and pro-oxidants depending on the concentration and free radical source. Tannin and catechin contents in fresh fruits and fruits in syrup in this study were analyzed using spectrophotometer according to the method of Brune, et al (1991) (66). The ranges of tannin and catechin contents in this study were 3.24 to 167.53 mg/100g of tannin equivalent (dry basis) and 0.13 to 82.81 mg/100g of catechin equivalent (dry basis), respectively. Sugar apple (Nahng variety) contained the highest tannin and catechin contents in the present study (167.53 mg/100g of tannin equivalent (dry basis) and 82.81 mg/100g of catechin equivalent (dry basis)). However, the data of tannin content in fruit were limited. When comparing the tannin value of sugar apple of our data with the highest tannin content in lead tree (*leucaena leucocephala*) from the report of Chanwitheesuk A., et al (2005) (85) indicated that tannin content of sugar apple of present study (43.37 mg/100g of tannin equivalent) was lower than tannin content of lead tree (60.6 mg/100g). In addition, catechin content in this study was between 0.01 to 21.44 mg/100g of catechin equivalent (edible portion). The amount of catechin in this study especially apple (Fuji; without peeled and Granny Smith; with peeled variety), grape (Green variety), mango (Kheosawoei; unripe, Nahmdawgmai; ripe and Rad; unripe variety) and strawberry were lower than those of the study of Arts et al (2000) (86) who determined the catechin content of fruits in the Netherlands,

found that the catechin content ranged from 7.11 to 11.54 mg/100g edible portion of seven varieties of apple, 3.92 to 20.39 mg/100g edible portion of two varieties of grape, 1.72 mg/100g edible portion of mango and 4.47 mg/100g edible portion of strawberry. The difference of catechin contents of our sample compared with those of Arts et al (2000) study might be due to the difference on the methodology that applied to determined catechin content of samples. Arts et al (2000) determined catechin in samples by using HPLC but our study used Spectrophotometer, this might be main cause for the difference between our results and those of Arts et al. (86). In addition, there are many factors which are known to be affected on the nutrient and non-nutrient content such as environmental condition, soil, seasonal variation, stage of maturity, storage condition, different method of sampling and preparing (76, 78, 87). Unfortunately, there are no other data available on tannin and catechin in Thai fruits. Therefore, comparing polyphenol content in this study with other publications was limited.

Consideration to the tannin and catechin content in the unit of milligram per one portion, tannin and catechin content per one portion was showed in Table 19. The excellent source of tannin was ripe mango (Nahmdawgmai varity) and strawberry (25.60 to 28.49 mg tannic acid equivalent/ portion) while the rich source of catechin content was sugar apple and star fruit (12.22 to 14.56 mg catechin equivalent/ portion).

Table 26 Comparison of the results obtained in this study with other publication

English name	Scientific name	Total polyphenol				
		Present study[1]	Present study[2]	Cieslik E. et al, 2006[3]	Karadenniz F. et al, 2005[3]	Rababah et al, 2005[4]
Apple		-	-	-	-	339.2
	Pyrus malus, Borkh.					-
	Fuji variety (not peeled)	164.09	24.41	-	-	-
	Granny Smith variety (peeled)	646.04	90.24	-	-	-
	Gara variety	-	-	964	-	
	Malus domestica B.	-	-	-	107.8	-
	Amasya variety	-	-	-	123.2	-
	Arapkizi variety	-	-	-	87.6	-
	Cooper variety	-	-	-	57.1	-
	Gloster variety	-	-	-	114.6	-
	Golden Delicious variety	-	-	-	54.1	-
	Granny Smith variety					

Table 26 Comparison of the results obtained in this study with other publication (Continued)

English name	Scientific name	Total polyphenol				
		Present study[1]	Present study[2]	Cieslik E. et al, 2006[3]	Karadenniz F. et al, 2005[3]	Rababah et al, 2005[4]
	Rome Beauty variety	-	-	-	111.0	-
	Starking variety	-	-	-	133.3	-
Banana (ripe)	*Musa sp.*					
	Hawm variety	368.3	90.35	-	-	-
	Musa sapientum;Linn					
	Kai variety	329.50	93.48	-	-	-
	Musa sapientum.					
	Nahmwah variety	291.72	96.09	-	-	-
Chinese pear	*Pyrus communis*					
	Ankara variety	-	-	-	34.5	-
	Deveci variety	-	-	-	32.6	-

Table 26 Comparison of the results obtained in this study with other publication (Continued)

English name	Scientific name	Total polyphenol				
		Present study[1]	Present study[2]	Cieslik E. et al, 2006[3]	Karadenniz F. et al, 2005[3]	Rababah et al, 2005[4]
	Hawm variety	203.94	29.75	-	-	-
	(not peeled)	106.32	14.63	-	-	-
	Namphung variety	-	-	-	47.3	-
	(peeled)					
	Santa Maria variety					
Dragon fruit	*Hylocereus spp.*	425.47	64.04	-	-	-
	Vietnam variety					
Durian	*Durio spp.*					
	Chanee variety	347.96	115.49	-	-	-
	Mawntong variety	606.95	176.61	-	-	-
Grape	*Vitis vinifera, L.*					
	Green variety	444.03	77.48	-	-	-
	Mü□küle variety	-	-	-	202.5	-
	Pink variety	-	-	683	-	-

Table 26 Comparison of the results obtained in this study with other publication (Continued)

English name	Scientific name	Total polyphenol				
		Present study[1]	Present study[2]	Cieslik E. et al, 2006[3]	Karadenniz F. et al, 2005[3]	Rababah et al, 2005[4]
	White variety	-	-	793	-	-
	Seedless variety	-	-	-	54.8	-
Guava	*Psidium guajava*					
	Pun-seetong variety	859.97	107.77	-	-	-
Jackfruit	*Artocapus heterophylla*	182.13	47.21	-	-	-
Longan	*Euphoria longana, Lamk.*					
	Kalokbew variety	495.86	100.03	-	-	-
Longkong	*Lansium domesticum Corr*	189.18	36.74	-	-	-
Lychee	*Litchi chinensis, Sonn.*					
	Hohnghooway variety	498.39	111.83	-	-	-
	Jackkrapat variety	670.80	117.37	-	-	-

Table 26 Comparison of the results obtained in this study with other publication (Continued)

English name	Scientific name	Total polyphenol				
		Present study[1]	Present study[2]	Cieslik E. et al, 2006[3]	Karadenniz F. et al, 2005[3]	Rababah et al, 2005[4]
Mango	*Mangifera indica*					
	Kheosawoei variety	315.19	65.18	-	-	-
(unripe)		397.13	79.24	-	-	-
	Nahmdawgmai variety	463.17	81.46	-	-	-
(ripe)						
	Rad variety (unripe)					
Mangosteen	*Garcinia mangostana*	438.70	86.90	-	-	-
Orange		-	-	1461	-	-
	Citrus sinesis Osb.					
	Clementine variety	494.66	61.17	-	-	-
	Sainuhmphung variety	475.75	67.13	-	-	-
Papaya	*Carica papaya, Linn.*					
(ripe)	Khak-dahm variety	45.44	4.67	-	-	-

Table 26 Comparison of the results obtained in this study with other publication (Continued)

English name	Scientific name	Total polyphenol				
		Present study[1]	Present study[2]	Cieslik E. et al, 2006[3]	Karadenniz F. et al, 2005[3]	Rababah et al, 2005[4]
Pineapple	*Ananas comosus, Merr.*	332.94	50.34	-	-	-
Pomelo	*Citrus maxima, Merr.*					
	Khaonahmpeung	321.04	37.87	-	-	-
	variety	289.26	32.58	-	-	-
	Tongdee variety					
Rambutan	*Nephelium lappaceum,*					
	Linn.	350.93	67.39	-	-	-
	Rong-rean variety					
Rose apple	*Syzygium samarangense*					
	Toon-klow variety	268.82	24.32	-	-	-
	Tup-tim-jun variety	178.00	19.67	-	-	-
Salacca	*Salacca sp.*	358.38	71.32	-	-	-
Sapodilla	*Achras sapota, L.*	235.47	57.63	-	-	-

Table 26 Comparison of the results obtained in this study with other publication (Continued)

English name	Scientific name	Total polyphenol				
		Present study[1]	Present study[2]	Cieslik E. et al, 2006[3]	Karadenniz F. et al, 2005[3]	Rababah et al, 2005[4]
Star fruit	*Averrhoa carambola*	1373.99	148.37	-	-	-
Strawberry	*Fragaria spp.*	2110.62	220.63	-	-	531.7
Sugar apple	*Auona sguamosa* Nahng variety	1246.23	322.63	-	-	-
Watermelon	*Citruluss vulgalis, Schrad.* Jin-trarah variety (red color)	252.45	28.20	-	-	-
	Jin-trarah variety (yellow color)	275.08	23.44	-	-	-

[1] Total polyphenol was expressed to mgGAE/100g (dry basis)
[2] Total polyphenol was expressed to mgGAE/100g (edible portion)
[3] Total polyphenol was expressed to mg/100g (dry wt)
[4] Total polyphenol was expressed to mg/100g (edible portion)

Table 26 Comparison of the results obtained in this study with other publication (Continued)

English name	Total polyphenol				
	Present study[1]	Present study[2]	Cieslik E. et al, 2006[3]	Karadenniz F. et al, 2005[3]	Rababah et al, 2005[4]
Fruit salad	183.66	39.00	-	-	-
Longan in syrup	132.42	27.75	-	-	-
Lychee in syrup	180.17	40.95	-	-	-
Rambutan in syrup	116.06	24.00	-	-	-

[1] Total polyphenol was expressed to mgGAE/100g (dry basis)
[2] Total polyphenol was expressed to mgGAE/100g (edible portion)
[3] Total polyphenol was expressed to mg/100g (dry wt)
[4] Total polyphenol was expressed to mg/100g (edible portion)

6.3 Phytate analysis of 39 fresh fruits and 4 fruits in syrup

Dietary phytate might have both negative and positive roles. Although, phytate can decrease mineral bioavailability and can contribute to mineral deficiency in populations in the developing world who consume rice, grains and cereal as staple foods, recent studies showed that dietary phytate might also have beneficial health effects, for example as an anti-cancer and antioxidant (88, 89). The negative effects of dietary phytate have the greatest impact on youth and growth in the developing world, whereas the positive effects of phytate are interesting in the pathologies of aging such as oxidative damage and cancer in the developed world. Phytate (inositol pentaphosphate (IP5) and inositol hexaphosphate (IP6)) contents in fresh and canned fruits were determined according to the method of Hotz and Gibson (2001) (67). Phytate content ranged from 0.10 to 40.00 mg/100 g dry basis or 0.01 to 6.02 mg/100 g edible portion. Joung H., et al (2004) demonstrated that the amount of phytate content of Korean food which was determined by anion-exchange and reading by spectrophotometer as reported in mg per 100g of food item were as follows: 191.7-973.3 mg in cereals; 508.5 - 1371.8 mg in legumes; 0.4 - 319.9 mg in vegetables; and 1- 50 mg in fruits. In case of fruits, Joung H., et al (2004) reported that phytate content of apple (Fuji variety), banana, and watermelon were 1.4, 3.2 and 2.9 mg/100 g (90). The values of banana and watermelon from the report of Joung H., et al (2004), were higher than those in this study [0.13 mg/100 g edible portion of ripe banana (Hawm variety), 0.43 mg/100 g edible portion of ripe banana (Kai variety), 0.39 mg/100 g edible portion of ripe banana (Nahm-wah variety) and 0.21 of watermelon (Jittarrah variety, yellow)], while phytate value of apple (Fuji variety) was similar to that of apple without peeled (Fuji variety) in this study (range from 0.91-2.79 mg/100 g wet wt). The difference in the data of phytate analysis was due to the different method for phytate measurement, different method of sampling and preparing. Because in this study used the HPLC method for determination of phytate content in form of IP4 (inositol tetraphosphate), IP5 (inositol pentaphosphate) and IP6 (inositol hexaphosphate) but Joung H., et al (2004) used an anion exchanged method and read their content by spectrophotometer. Therefore, using calorimetric method in Joung H., et al (2004) study for determination of phytate content in the form of phytate-phosphorus might be overestimated due to the calculation of phytic-phosphorus

included all the forms of phytic acid. It is not surprise why analysis data of phytate in our study was lower. Since in our method, we measured phytate only in form of IP4, IP5 and IP6 but not all the phytic acid forms. In addition, Sandberg (1986) (91) suggested that the precipitation and an anion exchange method were not specific as they did not separate the forms of phytate (inositol hexaphosphate;IP) and thus overestimated the phytate content in foods.

Moreover, the range of phytate in the unit of milligram per portion was 0.02 to 7.22 mg/portion. The highest of phytate content was found in dragon fruit (Vietnam variety) while the lowest of phytate content was found in rose apple (Tup-tin-jun variety).

Additional, the molar ratio of phytate to iron (Phy/Fe) or phytate to zinc (Phy/Zn) or calcium, phytate to zinc (Ca×Phy/Zn) are considered to be important for predicting mineral absorption or bioavailability in the diet. According to Glahn et al., in 2002 demonstrated that a Phy/Fe molar ratio greater than 10 inhibit iron uptake or iron absorption (92). In addition, Yang et al (2005) demonstrated that a Phy/Zn and Ca×Phy/Zn molar ratio greater than 10-20 and 200, respectively could have an inhibitory effect on zinc absorption (93). WHO, 1996 (94) reported that Phy/Zn molar ratio below 5 are designated as high zinc availability; ratios within the range of 5-15 was moderate availability; and ratios above 15 was low availability. The molar ratio of Phy/Fe, Phy/Zn and Phy×Ca/Zn as showed in Table 22. The molar ratio of Phy/Fe, Phy/Zn and Phy×Ca/Zn ranged from 0.00 : 1 to 2.60 : 1, 0.00 : 1 to 4.20 : 1 and 0.00 : 1 to 38.96 : 1, respectively. Consideration among the molar ratio by calculation from our data between the amount of phytate with some mineral such as Fe (Phy/Fe), Zn (Phy/Zn) and or Ca/Zn (Phy x Ca / Zn) of present study found that all selected fruit samples had lower molar ratio as Glahn et al (2002), Yang et al (2005) and WHO (1996) suggestion. Data of polyphenol, tannin and phytate contents indicated that all selected fresh fruits and fruits in syrup were high sources of polyphenol but not for phytate and tannin. Especially durian both in two varieties, guava, lychee in both variety, star fruit, strawberry and sugar apple were the excellent sources of polyphenol when compared to other fruit items.

CHAPTER VII
CONCLUSION

The different amount of macro - micro minerals (sodium; Na, potassium; K, calcium; Ca, magnesium; Mg, iron; Fe, zinc; Zn and copper; Cu), polyphenol, tannin, catechin and phytate contents are generally influenced by many factors such as cultivar of plant, soil and climate conditions during growing, agricultural practices, use of fertilizers, the state of the fruits maturity at harvest, storage conditions and transportation conditions before reaching to consumers. Many researches support the promise that high potassium intake can decrease blood pressure. However, at the end-stage of chronic renal failure, patients should be avoiding food with high potassium because it may contribute to malfunction of the heart muscle and death in the patients. This study found that the highest content of elements in the entire samples was potassium. The range of potassium in all fresh fruits and fruits in syrup was between 28.30 to 405.60 mg/100g edible portion. The highest sources of potassium were ripe banana (Kai and Hawm varieties) and durian (Chanee variety). The sodium content of fresh fruits and fruits in syrup ranged from 0.59 to 16.32 mg/100 g edible portion. The highest source of sodium was sapodilla. For calcium, the range of calcium was 1.17 to 22.09 mg/100 g edible portion. The highest source of calcium was orange (Clementine variety). Additional, the magnesium value of fresh fruits and fruits in syrup ranged from 3.08 to 25.21 mg/100 g edible portion while the highest source of magnesium was ripe banana (Hawm, Kai and Nahm-wah varieties), dragon fruit (Vietnam variety) and sugar apple (Nahng variety). For micro-minerals, all fresh fruits and fruits in syrup were contained low – very low amounts of iron, copper and zinc. A wide variation of iron content was ranged from 0.08 to 0.33 mg/100 g edible portion. The highest amount of iron was found in durian (Chanee variety), strawberry and ripe banana (Nahm-wah variety). Copper content in fresh fruits and fruits in syrup of this study was 0.04 to 0.27 mg/100 g edible portion. Longkong and durian (Chanee variety) were the highest sources of copper. The values of zinc content ranged

from 0.04 to 0.28 mg/100 g edible portion. And the high sources of zinc were found in jackfruit, durian (Chanee and Mawntong varieties) and grape (Green variety).

According to the recommendation of percent Thai RDI (the Ministry of Publish Health, 1998), good source of minerals should be around 10-19% and for and excellent source of minerals should be around more than 20%, except for sodium, when comparing the highest values of micro-macro mineral contents, polyphenol, tannin and phytate in one portion of fruits in this study to that suggestion, the results indicated that dragon fruit was good sources of potassium due to their providing potassium about 9% of Thai RDI. And other macro-minerals (Na, Ca and Mg) of the samples were not good source of minerals, due to the values were less than 10% Thai RDI. Especially, sodium, calcium and magnesium content supply only by about 0 - 4% of Thai RDI, except dragon fruit (Vietnam variety) provide about 8% for magnesium of Thai RDI. When considering micro-mineral value with percent Thai RDI, the good sources of copper were lychee; Hohnghooway variety (10%) and grape; Green variety (13%), but not for iron and zinc (less than 10% Thai RDI).

Polyphenolic compounds are expressed through their action as an inhibitor or an activator for a large variety of mammalian enzyme systems, and as metal chelators and scavenger of free oxygen redicals. Total polyphenol, tannin and catechin contents of fresh and canned fruits ranged from 4.67 to 322.63 mgGAE/100 g edible portion, 0.62 to 43.37 mg tannic acid equivalent/ 100g edible portion and 0.01 to 21.44 mg catechin equivalent /100g edible portion, respectively. Sugar apple was the highest of polyphenol, tannin and catechin content. The calculation of total polyphenol, tannin and catechin contents to one portion of each fruits were found that strawberry (397.13 mg GAE/portion and 28.49 mg tannic acid equivalent/portion) is the highest source of total polyphenol and tannin while star fruit (12.79 mg catechin equivalent/portion) is the highest source of catechin. For phytate, the range of phytate content was between 0.01 to 6.02 mg/100g edible portion. And the highest source of phytate both in per 100g edible portion and per one portion was dragon fruit (Vietnam variety). However, the molar ratio between phytate and micro-elements of all the fruit samples of present study less than 2.60 for Phy/Fe, 4.20 for Phy/Zn and 39 for Ca×Phy/Zn.

REFERENCES

1. World Health Organization. The world health report 2005. Preventing chronic diseases: a vital investment. Geneva: World Health Organization, 2005.
2. Murray CJL, Lopez AD. Mortality by cause for eight regions of the world: Global Burden of Disease Study. Lancet 1997; 349: 1269-1276.
3. World Health Organization. The world health report 1998. Life in the 21st century: a vision for all. Geneva: World Health Organization, 1998; 1-241.
4. Heikki Karppanen and Eero Mervaala. Sodium Intake and Hypertension. Prog Cardiovasc Dis. 2006; 49(2):59-75.
5. Ogihara T, Asano T, Fujita T. Contribution of salt intake to insulin resistance associated with hypertension. Life sciences 2003; 73: 509-523.
6. Burt VL, Whelton P, Roccella EJ, Brown C, Cutler JA, Higgins M, et al. Prevalence of hypertension in the US adult population. Results from the Third National Health and Nutrition Examination Survey, 1988-1991. Hypertension 1995;25(3):305-313.
7. สำนักงานปลัดกระทรวงสาธารณสุข. สถิติสาธารณสุข 2540. กรุงเทพ; 2540.
8. สำนักงานปลัดกระทรวงสาธารณสุข. สถิติสาธารณสุข 2541. กรุงเทพ; 2541.
9. สำนักงานปลัดกระทรวงสาธารณสุข. สถิติสาธารณสุข 2542. กรุงเทพ; 2542.
10. สำนักงานปลัดกระทรวงสาธารณสุข. สถิติสาธารณสุข 2543. กรุงเทพ; 2543.
11. สำนักงานปลัดกระทรวงสาธารณสุข. สถิติสาธารณสุข 2544. กรุงเทพ; 2544.
12. สำนักงานปลัดกระทรวงสาธารณสุข. สถิติสาธารณสุข 2545. กรุงเทพ; 2545.
13. สำนักงานปลัดกระทรวงสาธารณสุข. สถิติสาธารณสุข 2546. กรุงเทพ; 2546.
14. สำนักงานปลัดกระทรวงสาธารณสุข. สถิติสาธารณสุข 2547. กรุงเทพ; 2547.
15. Coresh J, Astor BC, Greene T, Eknoyan G, Levey AS. Prevalence of chronic kidney disease and decreased kidney function in the adult US population:

Third National Health and Nutrition Examination Survey. Am J Kidney Dis 2003; 41: 1-12.

16. Chadban SJ, Briganti EM, Kerr PG, Dunstan DW, Welborn TA, Zimmet PZ, et al. Prevalence of kidney damage in Australian adults: The AusDiab kidney study. J Am Soc Nephrol 2003; 14: S131-138.
17. Ramirez SP, McClellan W, Port FK, Hsu SI. Risk actors for Proteinuria in a large, multiracial, southeast Asian population. J Am Soc Nephrol 2002; 13:907-917.
18. Chittinandana A. Thailand renal replacement therapy registry, TRT Registry. Report 1997-2000. J Nephrol Soc Thai 2002; 8:167-179.
19. Liu S, Manson J, Lee M, Cole S, Hennekens C, Willett W, Buring J. Fruit and vegetable intake and risk of cardiovascular disease: the Women's Health Study. Am J Clin Nutr 2000;72:922–928.
20. Hung H, Joshipura K, Jiang R, Hu F, Hunter D, Smith-Warner S, Colditz G, Rosner B. Fruit and Vegetable Intake and Risk of Major Chronic Disease. J Natl Cancer Inst 2004; 96:1577-1584.
21. Dauchet L, Amouyel P, Hercberg S, Dallongeville J. Fruit and Vegetable Consumption and Risk of Coronary Heart Disease: A Meta-Analysis of Cohort Studies. J. Nutr 2006;136: 2588–2593.
22. Lancaster KJ, Wright HS, Weitzel LB, Mitchell DC, Friedmann JM, Jensen GL, Hypertension-related dietary patterns of rural older adults. Preventive Med 2004;38:812-818.
23. Pollard J, Greenwood D, Kirk S, Cade J. Lifestyle factors affecting fruit and vegetable consumption in the UKWomen's Cohort Study. Appetite 2001;37: 71-79.
24. Food and Nutrition Board. Recommended Dietary Allowances, Ninth Revised Edition. Washington, D.C. National Academy of Sciences, National Research Council, 1980.
25. Groff JL. Advanced nutrition and human metabolism. 3rd ed. Belmont, California: Wadsworth/Thomson Learning; 2000:p.373-385.
26. Williams & Wilkins. Modern nutrition in health and disease. 9 ed. Baltimore: Md. A waverly company, 1999: 393-395.

27. Leiba A, Vald A, Peleg E, Shamiss A, Grossman E. Does dietary recall adequately assess sodium, potassium, and calcium intake in hypertension patients? Nutrition 2005; 21:462-466.

28. Elliott P, Stamler J, Nichols R, Dyer AR, Stamler R, Kesteloot H, Marmot M. Intersalt revisited: further analyses of 24 hour sodium excretion and blood pressure within and across populations. Intersalt Cooperative Research Group. BMJ 1996;312(7041):1249-1253.

29. Stamler J. The INTERSALT Study: background, methods, findings, and implications [published erratum appears in Am J Clin Nutr 1997 Nov;66(5):1297] Am J Clin Nutr 1997;65(2):626S-642.

30. Intersalt: an international study of electrolyte excretion and blood pressure. Results for 24 hour urinary sodium and potassium excretion. Intersalt Cooperative Research Group. BMJ 1988;297(6644):319-328.

31. He J, Whelton PK, Appel LJ, Charleston J, Klag MJ. Long-term effects of weight loss and dietary sodium reduction on incidence of hypertension. Hypertension 2000;35(2):544-549.

32. Judith A, Vinod K. Medical nutrition therapy in chronic kidney disease failure: integrating clinical practice guidelines. J Am Diet Assoc. 2004; 104:404 409

33. Judith A. Which diet for which renal failure: Making sense of the options. J Am Diet Assoc. 1995; 95:898-903.

34. Notification of the Ministry of Public Health number 182 (B.E. 2541) Re: Nutrition Labeling.

35. Andreoli TE, Carpentr CCJ, Plum F, Smith LHJR. Cecil Essentials of Medicine. 2nd ed. Philadelphia: W.B. Saunders Company, 1990: 196-197.

36. Schrier RW. Renal and Electrolyte Disorders. 2nd ed. Boston, Little Brown and Company, 1980: 184-189.

37. Osorio V, Linas L. Disorders of potassium metabolism: Available from: URL: http://www.kidneyatlas.org/book1/adk1_03.pdf. [Accessed 2007 Apr 28].

38. Franzoni F, Santoro G, Carpi A, Da Prato F, Bartolomucci F, Femia FR, et al. Antihypertensive effect of oral potassium aspartate supplementation in mild to moderate arterial hypertension. Biomed Pharmacother. 2005;59(1-2):25-

29.

39. Whelton PK, He J, Cutler JA, Brancati FL, Appel LJ, Follmann D, Klag MJ. Effects of oral potassium on blood pressure. Meta-analysis of randomized controlled clinical trials. JAMA 1997;277(20):1624-1632.
40. Williams SR, Schlenker ED. Essentials of nutrition and diet therapy. 6th ed. St.Louis: Mosby; 1994: p.134-139.
41. Eshleman MM. Minerals. Introductory nutrition and nutrition therapy. 3rd ed. Philadelphia: Lippincott; 1996: p.192-218.
42. Dwyer JH, Dwyer KM, Scribner RA, Sun P, Li L, Nicholson LM, Davis IJ, Hohn AR. Dietary calcium, calcium supplementation and blood pressure in African American adolescents. Am J Clin Nutr. 1998; 68:648-655.
43. Griffith LE, Guyatt GH, Cook RJ, Bucher HC, Cook DJ. The influence of dietary and nondietary calcium supplementation on blood pressure: an updated meta-analysis of randomized controlled trials. Am J Hypertens. 1999;12: 84-92.
44. Domenic S. Calcium channel blocker and the kidney. Clinical Cornerstone 2004; 6:39-52.
45. Chetan P. Hans, R.sialy and Devi D. Bansal. Magnesium deficiency and diabetes mellitus. Current Science. 2002; 83:1456-1458.
46. Barbagallo M, Dominguez LJ. Magnesium metabolism in type 2 diabetes mellitus, metabolic syndrome and insulin resistance. Arch Biochem Biophys 2007; 458:40-47.
47. Paolisso G, Barbagallo M. Hypertension, diabetes mellitus, and insulin resistance. The role of intracellular magnesium. Am J Hypertens 1997;10:346-355.
48. Barbagallo M, Shan J, Pang PKT, Resnick LM. Glucose-induced alterations of cytosolic free calcium in cultured rat tail artery vascular smooth muscle cells. J Clin Invest 1995;95:763-767.
49. Saris N-EL, Mervaala E, Karppanen H, Khawaja JA, Lewenstam A. An update on physiological, clinical and analytical aspects. Clinica Chimica Acta 2000;294:1-26.
50. Kisters K, Wessels F, Kuper H, Tokmak F, Krefting ER, Gremmler B, Kosch M, Barenbrock M, Hausberg M. Increased calcium and decreased magnesium

concentrations and an increased calcium/magnesium ratio in spontaneously hypertensive rats versus Wister-Kyoto rats: relation to arteriosclerosis. Am J Hypertens 2004; 17:59-62.

51. Touyz RM and Milne FJ. Magnesium supplementation attenuates, but does not prevent, development of hypertension in spontaneously hypertensive rats. Am J Hypertens 1999;12:757–765.
52. Cook DJ. Adaptation in iron metabolism. Am J Clin Nutr. 1990; 51:301-308.
53. Groff JL. Advanced nutrition and human metabolism. 3rd ed. Belmont, California: Wadsworth/Thomson Learning; 2000:p402-450.
54. Kumar N, Gross JB, Ahlskog JE. Copper deficiency myelopathy produces a clinical picture like subacute combined degeneration. Neurology 2004; 63:33-39.
55. Esfahani ST, Hamidian MR, Madani A, Ataei N, Mohseni P, Roudbari M, Haddadi M. Serum zinc and copper levels in children with chronic renal failure. Pediatr Nephrol 2006;21:1153–1156.
56. Fereidoon S, Marian N. Phenolics in Food and Nutraceuticals. CRC Press. 2004.
57. Brune M, Rossander L, Hall berg L. Iron absorption: no intestinal adaptation to a high phytate diet. Am J Clin Nutr 1989; 49:542-545.
58. Reddy NR, Sathe SK. Food phytates. CRC Press. 2002.
59. Harland BF and Morris ER Phytate: a good or a bad food component. Nutr. Res. 1995;15:733–15754.
60. Grafs E, Empson K, Eaton JW. Phytic acid: a natural antioxidant. J. Biol. Chem. 1987;262:11647-11650.
61. Thai Fruits. Available from: URL : www.ku.ac.th/AgrInfo/fruit/product/index.html
62. Association of Official Analytical Chemist (AOAC). Official Method of Association of Official Analytical Chemist (Horwitz W., ed) 17th ed. Maryland Method 920.151, 930.30
63. Association of Official Chemists. Official Methods of Analysis of AOAC. 12th ed. Washington DC: Association of Official Chemists, Inc., 1975.
64. Analytical methods for Flame atomic absorption spectrometry, Varian Australia Pty. Ltd., 1989.
65. Clegg MS, Keem CL, Lonnadal B, Hurley LS. Influence of ashing techniques on

the analysis of trace elements in animal tissue (1); Wet ashing. Biol Trace Elem Res 1981;3:107-115.

66. Brune M, Hallbergs L, Skanberg AB. Determination of iron-binding phenolic groups in foods. J Food Sci 1991;56:128-131.

67. Hotz C, Gibson RS. Assessment of home-base processing methods to reduce the phytate content and phytate/zinc molar ratio of maize (Zeamays). J Agric Food Chem 2001;49:692-698.

68. Food Exchange list. Available from: URL : www.nhlbi.nih.gov/health/public/heart/obesity/lose_wt/fd_exch.htm#4.com

69. Puwastien P, Raroengwichit M, Sungpuag P, Judprasong K. Thai food composition tables. 1st ed. Bangkok. Paluk Tai Co., Ltd. 1999.

70. Sanchez-Castillo CP, Dewey PJS, Aguirre A, Lara JJ, Vaca R, Barra PL, Ortiz M, Escamilla I, James WP. The Mineral Content of Mexican Fruits and Vegetables. J Food Compost Anal 1998;11:340-356.

71. Leterme P, Buldgen A, Estrada F, Londono AM. Mineral content of tropical fruits of the Andes and the rain forest of Colombia. Food Chem 2005;4:644-652.

72. Wall MM. Ascorbic acid, vitamin A and mineral composition of banana (*Musa sp.*) and papaya (*Carica papaya*) cultivars grown in Hawaii. J Food Compost Anal 2006;19:434-445.

73. Wall MM. Ascorbic acid and mineral composition of longan (*Dimocarpus longan*), lychee (*Lichit chinensis*) and rambutan (*Nephelium lappaceum*) cultivars grown in Haweii. J Food Compost Anal 2006;19:655-663.

74. Hardisson A, Rubio C, Baez A, Martin M, Alvarez R, Diaz E. Mineral composition of the banana (*Musa acuminata*) from the island of Tenerife. Food Chem 2001;73:153-161.

75. World Health Organization. The world health report 2003. Diet, nutrition and the prevention of chronic disease. Geneva: World Health Organization, 2003.

76. Forster MP, Rodriguez ER, Martin JD, Romero CD. Statistical differentiation of banana according to their mineral composition. J Agirc Food Chem 2002; 50:6130-6135.

77. Kongkachuichai R. Macro-element contents in Thai vegetables and fruits. J Nutr Assoc Thai 1990; 24:Jan-Mar

78. Hakala M, Lapvetelainen A, Huopalahti R, Kallio H, Tahvonen R. Effects of varieties and cultivation conditions on the composition of strawberries. J Food Compost Anal 2003;16:67-80.

79. Garbisa S, Sartor L, Biggin S, Salvato B, Beneli R, Albini A. Tumor gelatinases and invasion inhibited by the green tea flavanol epigallocatechin-3-gallate. Cancer 2001;91:822-832.

80. Cieslik E, Greda A, Adamus W. Contents of polyphenols in fruits and vegetables. Food Chem 2006;94:135-142

81. Rababah TM, Ereifej K, Howard L. Effect of ascorbic acid and dehydration on concentrations of total phenolics, antioxidant capacity, anthocyanins, and color in fruits. J Agric Food Chem 2005;53:4444-4447.

82. Karadeniz F, Burdurlu HS, Koca N, Soyer Y. Antioxidant activity of selected fruits and vegetables grown in Turkey. Turk J Agric For 2005;29:297-303.

83. Chung KT, Wong TY, Wei CI, Huang YW, Lin Y. Tannins and human health: A review. Crit Rev Food Sci Nutr 1998;38:421-464.

84. Varanka Z, Rojik I, Varanka I, Nemcsok J, Abraham M. Biochemical and morphological changes in carp (*Cyprinus carpio* L.) liver following exposure to copper sulfate and tannic acid. Comp Biochem Physiol C 2001;128:467-478.

85. Chanwitheesuk A, Teerawutgulrag A, Rakariyatham N. Screening of antioxidant activity and antioxidant compounds of some edible plants of Thailand. Food Chem 2005;92:491-497.

86. Art ICW, Putte B, Hollman PCH. Catechin contents of foods commonly consumed in the Netherlands. 1. Fruits, vegetables, staple foods, and processed foods. J Agric Food Chem 2000;48:1746-1751.

87. Ekholm P, Reinivuo H, Mattila P, Pakkala H, Koponen J, Happonen A, Hellstrom J, Ovaskainen ML. Changes in the mineral and trance element contents of cereals, fruits and vegetables in Finland. J Food Compost Anal 2007;6:487-495.

88. Harland BF, Morris ER. Phytate: a good or a bad food component? Nutr Res 1995; 15:733-754.

89. Graf E, Empson KL. Phytic acid: a natural antioxidant. J Biol Chem

1987;262:11647-11650.

90. Joung H, Nam G, Yoon S, Lee J, Shim JE, Paik HY. Bioavailable zinc intake of Korean adults in relation to the phytate content of Korean foods. J Food Compost Anal 2004;17:713-724.

91. Sandberg AS, Ahderinne R. HPLC method for determination of inositol tri-, tetra-, penta-, and hexaphosphates in foods and intestinal contents. J Food Sci 1986;51:547-550.

92. Glahin RP, Wortley GM. Inhibition of iron uptake by phytic acid, tannic acid, and $ZnCl_2$: Studies using an in vitro digestion/Caco-2 cell model. J Agric Food Chem 2002;50:390-395.

93. Yang L, Yang X, Jianhua P, Yuan T, Li P, Wang Y, Wang J. Studies on zinc bioavailability from a representative diet in Chinese urban women of childbearing age using a double label stable isotope technique. J Trace Elem Med Biol 2005;19:159-164.

94. World Health Organization. The world health report 1996. Trace elements in human nutrition and health, Geneva: World Health Organization, 2003.

APPENDIX

APPENDIX A

Determination of moisture

Hot-air-oven method; AOAC 2000, 920.151

Principle:

A well homogeneous sample is dried in an oven (usually at 100 ± 5 ° C) until constant weight is obtained. The loss of weight is taken as a measure of moisture content in the sample. Acid washed sand is used to mix with the wet sample prior to dry in order to increase area for rapid and complete evaporation of water from the wet sample.

Procedure:

1. Weigh approximately 20 g of acid washed sand into a porcelain dish containing a small glass stirring rod and dry in hot air oven at 100 ± 5 ° C for 30 min.
2. Remove the sand dish and cool in the desiccator.
3. Weigh sand dish (=a g) and then approximately 5 g sample. Reweigh(=b g)
4. Add small amount of distilled water to disperse the sample evenly and evaporate the water as mush possible on the boiling water bath. The sample dish should be frequently mix until dries.
5. Transfer the sample dish to hot air oven and dry the sample at 100 ± 5 ° C for 2 hr.
6. Remove the sample dish and cool in a desiccator and weigh (=c g)
7. Return the sample dish to the hot air oven and dry until a constant weight is obtained. Reweigh every 30 min.
8. The different weight between each interval time should not be more than 1-3 mg

Calculation:

$$\% \text{ Moisture} = \frac{(b-c)}{(b-a)} \times 100 \text{ (w/w)}$$

APPENDIX B

Determination of Ash (Dry ashing)

AOAC 2000, 930.30

Principle:

The ash content is determined by incinerating a known quality of foodstuff, previously dried, in a muffle furnance at 550°C until constant weight. The residue (the ash) is dissolved in acid solution, then subjected to analysis of minerals (Sodium and potassium were determined from the ash obtained)

Reagent and Instrument:

1. 50% nitric acid
2. Porcelain crucible
3. Muffle furnace
4. Hot air oven
5. Bunsen burner

Preparation of the solution of the ash

1. Add about 10% (v/v) of 4N HNO_3 into the crucible containing weighed ash.
2. Use glass rod to mix and dissolve the ash with acid.
3. Transfer and filter the content into an appropriate volumetric flask (20-100 ml). Rinse the crucible several times with deionized water before making up to volume.
4. Transfer the solution in to the bottle and keep in the refrigerator at 4°C for the analysis of minerals.

Procedure

1. Dried acid washed porcelain crucibles in the furnace at 550°C for 30 min.
2. Cool the crucible in a desiccator for 20 min. Weighed, nearest to 1 mg(=a g)
3. Weighed exactly 2-5 g of homogeneous sample into the weighed crucible.

4. Heat the dried sample over a low flame of bunsen burner or on an electric hot plate until clear. This is to burn away some of organic matter.
5. Incinerated the charred sample in a furnace at 550°C for 2 hr. (or until complete ashing) was obtained (white or light gray ash). Removed the crucible and cooled in a desiccator.
6. If the sample is not completely ashed, still dark grey or black, add 2 ml 50% (v/v) nitric acid. Evaporate off the acid and dry the sample over the flame or heater and reincinerated until complete ashing is obtained.
7. Weigh with accuracy of 1 mg (= b g).

Calculation:

$$\text{Ash} = \frac{(b\text{-}a) \times 100}{\text{weight or volume of sample}} \quad \%w/w \text{ or } \% w/v$$

APPENDIX C

Determination of sodium and potassium by Atomic Absorption Spectrophotometry

Principle:

Dry ashing method is suitable for sample preparation. These techniques generally remove the bulk of the organic material; the ash may be extracted with a dilute acid, preferable nitric acid. After a suitable dilution, the sodium and potassium determined y flame atomic absorption spectrophotometer (AAS).

Reagents for sodium determination:

1. 4N Nitric acid
2. Stock sodium solution: stock solution sodium chloride solution 1,000 ppm (100 mg% or 1,000 μg/ml), were obtained from Merck Company. Or dissolve 2.5426 g of dry sodium chloride (analytical grade) in 1,000 ml deionized distilled water.
3. Working standard solution: Prepare a set of sodium solution, containing 10, 30, 50 and 100 μg/ml, from stock standard solution. Add 4N nitric (v/v) of final solution.
4. Blank: Prepare blank solution containing 10% (v/v) 4N nitric acid.

Reagents for potassium determination:

1. 4N Nitric acid
2. Stock potassium solution: stock solution potassium chloride solution 1,000 ppm (100 mg% or 1,000 μg/ml), were obtained from Merck Company. Or dissolve 1.9066 g of dry potassium chloride (analytical grade) in 1,000 ml deionized distilled water.
3. Working standard solution: Prepare a set of potassium solution, containing 10, 20 μg/ml, from stock standard solution. Add 4N nitric (v/v) of final solution.
4. Blank: Prepare blank solution containing 10% (v/v) 4N nitric acid

Procedure:

1. Set up the AAS according to the instruction as follow:

   Recommended instrument setting:

Flame	Air/Acethylene
Lamp current	5 mA
Spectral band pass	0.5 nm
Wavelength	330.3 nm (for sodium), 404.4 nm (for potassium)
Flame stoichiometry	oxidizing

2. Set the absorbance of the zero by using blank or deionized water and then measure the absorbance of the standard solutions.
3. Measure the absorbance of the sample solution. If the absorbance of sample solution is too high, dilute and repeat the measurement.

Calculation:

1. Prepare a calibration graph of absorbance against concentration.
2. Calculate the sodium and potassium contents of the original food given from the measured absorbance.

APPENDIX D

Determination of Calcium, Magnesium, Iron, Zinc and Copper (Wet digestion)

Principle:

Wet ashing technique was used to prepare the sample for the determination of calcium, magnesium, iron, copper and zinc content. The samples were digested by nitric acid and perchloric acid at ratio 5:1 and then determined the iron content using inductively coupled plasma- optical emission Spectrometry (ICP-OES) at different wavelength.

Reagent:

1. Conc. nitric acid (Merck # 1.00456.2500)
2. Conc. perchloric acid (JT Baker 3 9625-04)
3. Calcium standard solution (Merck # 1.09943): Stock standard solution (1000 ppm)
4. Magnesium standard solution (Merck # 1.09949): Stock standard solution (1000 ppm)
5. Ferric standard solution (Merck # 1.09972): Stock standard solution (1000 ppm)
6. Zinc standard solution (Merck # 1.09953): Stock standard solution (1000 ppm)
7. Copper standard solution (Merck # 1.09987): Stock standard solution (1000 ppm)

Instrument:

1. Teflon
2. Volumetric flask
3. Funnels
4. inductively coupled plasma- optical emission Spectrometry (ICP-OES)

Procedure:

1. Weigh 2 g of the sample (depending on expected iron content) into teflon jar.
2. Add 5 ml conc. Nitric acid and 1 ml Perchloric acid to each of teflon sample and tightly covered with lids.
3. Keep the teflon sample under fume hood at room temperature for predigestion overnight.
4. Place the teflon sample in hot air oven at 100-120 °C about 8-12 hrs or until the solution clear.
5. Transfer the digested sample to an appropriate volume of volumetric flask and dilute with deionized distilled water.
6. Measure the diluted sample, working standard iron and reagent blank by inductively coupled plasma- optical emission Spectrometry (ICP-OES)
7. Wavelength for determination of mineral

Mineral	**Wavelength (nm)**
Calcium	317.933
Magnesium	279.077
Iron	238.204
Zinc	206.200
Copper	327.393

APPENDIX E

Determination of total polyphenol by the Folin-Ciocalteu method

Principle:

The polyphenol contained in a dry food sample are extracted in a organic solvent. The extracted polyphenols are then quantified by spectrophotometer after reaction with the Folin-Ciocalteu reagent.

Chemicals:

1. Dimethylformamide (Carloerba reagent # 444923)
2. Sodium acetate (Merck # 106268)
3. Glacial acetic acid (Merck # 100063)
4. Hydrochloric acid, 37% (Merck # 100317)
5. Folin-Ciocalteu reagent (Merck # 109001)
6. Sodium hydroxide , NaOH (Merck # 106498)
7. Gallic acid monohydrate (Riedel-deHaen # 27645)

Apparatus:

- UV/VIS spectrophotometer (TECAN sunrise remote control microplate reader)
- Shaking machine (Gyrotary water bath shaker model G76)

Reagent preparation:

- O.1 M acetate buffer pH 4.4:

  Solution A - 11.6 ml glacial acetic acid dilute to 1000 ml with deionized distilled water

  Solution B - 16.4 g sodium acetate anhydrous dilute to 1000 ml with deionized distilled water

Acetate buffer solution: mix solution A 305 ml and solution B 195 ml and adjust to 1000 ml with deionized distill water; adjust pH to 4.4 with 0.5 M NaOH

- Extraction reagent: mix equal volumes (500 ml + 500 ml) of dimethylformamide (DMF) and acetate buffer.
- Folin-Ciocalteu's reagent (FCR): dilute 10 ml of FCR stock solution to 100 ml with water in a volumetric flask.
- 0.2 M HCl: fill a 500 ml volumetric flask with ca. 400 ml water; add 8.3 ml HCl 32% and fill up to the mark with water.
- 0.5 M NaOH: weigh 10 g of NaOH in a 500 ml volumetric flask; add about 400 ml water, and after dissolution and when the solution has cooled down, fill up to the mark with water.
- Gallic acid solution 1 mg GA/ml: weigh precisely 110 mg of gallic acid monohydrate in a 100 ml volumetric flask, dissolve and fill up to the mark with water
- Gallic acid, 100 µg GA/ml: dilute 10 ml of GA solution (1 mg/ml) to 100 ml with water
- Gallic acid working standard solutions: pipette respectively 1.0 ml – 2.0 ml – 4.0 ml – 6.0 ml-8.0ml into tubes; add 2 ml of DMF/acetate mixture; fill up to 10 ml with water (GA concentrations: 10 µg/ml – 20 µg/ml – 40 µg/ml – 60µg/ml -80 µg/ml

Safety: dimethylformamide is toxic, especially for pregnant women!

Procedure:

a) extraction

- Weigh 50 to 2000 mg of dried sample (depending on expected polyphenol content) into a 100 flask.
- Add 50 ml of DMF/acetate buffer mixture and close the flask tightly.
- Extract for 16 hrs in the dark on a shaking machine
- Filter the mixture over a folded filter
- After filtration, pipette 1 ml of extract into a tube and add 4 ml of water

- Prepare 2 micro plates, one for the FCR reaction, the other for the determination of the own color from the samples.
- Fill both plates as follow:

	1	2	3	4	5	6	7	8	9	10	11	12
A	Blank	GA 1	GA 2	GA 3	GA 4	GA 5						
B	Blank	GA 1	GA 2	GA 3	GA 4	GA 5						
C	Sa. 1	Sa. 2	Sa. 3	Sa. 4	Sa. 5	Sa. 6	Sa. 7	Sa. 8	Sa. 9	Sa. 10	Sa. 11	Sa. 12
D	Sa. 1	Sa. 2	Sa. 3	Sa. 4	Sa. 5	Sa. 6	Sa. 7	Sa. 8	Sa. 9	Sa. 10	Sa. 11	Sa. 12
E	Sa. 13	Sa. 14	Sa. 15	Sa. 16	Sa. 17	Sa. 18	Sa. 19	Sa. 20	Sa. 21	Sa. 22	Sa. 23	Sa. 24
F	Sa. 13	Sa. 14	Sa. 15	Sa. 16	Sa. 17	Sa. 18	Sa. 19	Sa. 20	Sa. 21	Sa. 22	Sa. 23	Sa. 24
G	Sa. 25	Sa. 26	Sa. 27	Sa. 28	Sa. 29	Sa. 30	Sa. 31	Sa. 32	Sa. 33	Sa. 34	Sa. 35	Sa. 36
H	Sa. 25	Sa. 26	Sa. 27	Sa. 28	Sa. 29	Sa. 30	Sa. 31	Sa. 32	Sa. 33	Sa. 34	Sa. 35	Sa. 36

Where:

Blank: 25 µl diluted DMF/acetate

GA: 25 µl of gallic acid standard

SA: 25 µl of sample

  - On the lines A and B, pipette 25 µl of the standard solution (2 wells per concentration), and blanks
  - Pipette 25 µl of the sample extracts in duplicates

- The first plate will be the sample blank plate, without the reaction with FCR
  - Using the mutichannel pipette, add 125 µl of HCl 0.2 M to each well

- Add 100 µl of NaOH 0.5 M to each well
- Shake the plate briefly

- The reaction with FCR will occur on the second plate:
  - Using the multichannel pipette, add 125 µl of FCR to each well, as quick as possible
  - One minute after the addition of FCR, add 100 µl of NaOH 0.5 M to each well
- Read the FCR plate at 750 nm about 15 min after the addition of NaOH
- Read the sample bkanlplate at the same wavelength.

Calculations:

- Subtract the absorbance of the color reference plate from the FCR plate.
- For the calculation, select the sample dilute to which they will gives an absorbance value about the middle of the calibration curve.

APPENDIX F

Determination of tannin

(Spectrophotometric assay)

Principle:

Phenolic compounds were extracted from dry or freeze-dried food samples by dimethylformamide (DMF) in acetate buffer. A ferric ammonium sulfate reagent (FAS-reagent) was added, and the resulting color read spectrophotometrically against a reagent blank at two wavelengths corresponding to the absorbance maxima of iron-galloyl (blue color) and iron-catechol (green color) complexes. After subtracting food blank absorbance, the content of catechol groups (expressed as catechin equivalents) and galloyl groups (expressed as tannic acid equivalents) were calculated from standard curves for catechin and tannic acid at 578 and 680 nm.

Reagents:

1. Standard Tannic acid 1000 µg/ml (Sigma # T-0125) and (I)-Catechin 1000 µg/ml (Sigma # C-1788) – weight each standard 0.05 g and dilute to 50 ml with 50% DMF acetate
2. 0.1 M acetate buffer solution, pH 4.4

   Solution A - 11.6 ml glacial acetic acid (Merck 1.00063.2500) dilute to 1000 ml with deionized distilled water.

   Solution B - 16.4 d sodium acetate anhydrous dilute to 1000 ml with deionized distilled water.

   - or 27.2 g sodium acetate trihydrate (Merck # 1.06267.1000) dilute to 1000 ml with deionized distilled water.

Table 27 Acetate buffer solution preparation

Acetate buffer, pH 4.4 (ml)	Solution A (ml)	Solution B (ml)	Adjust pH 4.4 with o.5 NaOH	Made to vol. with DI*
1000	305	195	X	1000

* DI: Deionized distilled water.

3. 50 % DMF (N,N-dimethylformamide) (Carloerba reagent # 444923) in acetate buffer, pH 4.4 solution. 50% DMF – acetate was made equal volumes of DMF and 0.1 M acetate buffer, pH 4.4. A solution of the mixture was cooled to room temperature before use.
4. 50% urea (Univar # 817) in acetate buffer, pH 4.4 solution A 50% (weight/volume) urea – acetate solution was prepared by dissolving 500 g urea in 500 ml 0.1 M acetate buffer, pH 4.4.
5. 1% gum Arabic (Sigma # G-9752) solution. Dissolve with deionized distilled water.
6. Ferric ammonium sulfate (5% FAS reagent)(Merck # 1.03776) was dissolved in 1 M HCl (Merck # 1.00317.2500)

Instruments:

1. Filler paper whatman # 42 and funnel
2. Spectrophotometer (Unicam)
3. Vortex mixer
4. Test tubes
5. Pipettes
6. Volumetric flasks

Procedure:

1. Standard solutions of tannic acid and catechin in DMF-acetate were prepared, five solutions were made at concentrations between 50 and 400 µg/ml. standard solutions were stable up to 1 week, when stored in darkness.

Table 28 Preparing working standard of tannin (concentration 25-400 µg/ml)

Concentration (µg/ml)	Volume pipette (ml)	Final volume (ml)
25	0.25	10
50	0.50	10
100	1	10
200	2	10
400	4	10

2. A dry food sample was extraction; 50-2000 mg (depending on expected phenolic content) was placed in a 125 ml flask. Fifty ml DMF – acetate was added and the stoppered flask was mixed in a shaking machine for 16 hr in darkness at room temperature. The extract was filtered through folder filter paper # 42.
3. prepare an iron-containing reagent (FAS-reagent) was made by mixing, just before use, 89 parts of 50% urea-acetate, 10 parts of gum Arabic solution and 1 part of ferric ammonium sulfate solution. A food blank reagent was made by mixing, just before use, 89 parts of 50% urea-acetate buffer, 10 parts of gum arabic solution and 1 part of 1 M HCl.

Table 29 Iron-containing reagent (FAS-reagent) and food blank reagent.

Reagents	Food sample blank (ml)	Unknown FAS reagent (ml)
50% urea-acetate buffer	89	89
1% Arabic gum	10	10
1N HCl	1	-
5% FAS	-	1

4. Pipette 1 ml of the filtered extract was placed in a 10 ml test-tube and 4 ml of fresh FAS-reagent was added. After 15 min, the absorbance of the food samples at 578 nm and 680 nm were read versus a reagent blank consisting of 1 ml DMF-acetate and 4 ml FAS-reagent. A food blank was made by mixing 1 ml of the filtrate with 4 ml food blank reagent in a 10 ml test-tube. The absorbances at 578 nm and 680 nm were read versus a blank consisting of 1 ml DMF-acetate and 4 ml of food blank reagent. The absorbances thus obtained were measurements of the food sample base color and was subtracted (see calculation) from food blanks, reagent blank, food samples and standard curves were read in the same series and made in duplicate.

Calculation:

The food blank absorbance was subtracted from the food sample absorbance at 578 nm and 680 nm. The absorbance spectra of the two kinds of Fe-phenolic

complexes overlapped. The content of galloyl and catechol groups in the sample was, therefore, calculated using linear regression equiptions for the four standard curves, tannic acid (galloyl groups) and catechin (catechol groups) at the two wavelengths. The resulting equation set was readily solved with a programmable calculator.

1. Abbreviations

A. Unknown sample;

N578 = Net sample extinction at 578 nm

N680 = Net sample extinction at 680 nm

SW = Sample weight in grams

B. Standard solutions

St.ext TA 578 = Standard extinction tannic acid at 578 nm

St.ext TA 680 = Standard extinction tannic acid at 680 nm

St.ext TA 578 = Standard extinction catechin at 578 nm

St.ext TA 680 = Standard extinction catechin at 680 nm

St.cone.T = Standard concentration tannic acid (µg/ml)

St.cone.C = Standard concentration catechin (µg/ml)

Text.578 = True extinction at 578 nm (tannin extinction)

Text.680 = True extinction at 680 nm (catechin extinction)

2. Calculations

A. Extinction ration of standard:

$$K1 = \frac{\text{St.ext C578}}{\text{St.ext C 680}}$$

$$K2 = \frac{\text{St.ext TA578}}{\text{St.ext TA 680}}$$

B. Calculation of content of tannin and catechin in unknown samples

Step I. Calculation of true extinctions:

$$\text{T ext.578} = \frac{N^{578} - K_1 N^{680}}{1 - K_1 K_2}$$

$$T\ ext.680 = \frac{N^{680} - K_1 N^{578}}{1 - K_1 K_2}$$

Step II. Calculation of amount of catechin equivalents (mg/100g) and tannin equivalents (mg/100g)

$$\text{Tannin equivalents (mg/100g)} = \frac{St.conc\ TA \times 50 \times T\ ext.578}{SW \times ST.\ ext.\ TA\ 578} \times 100$$

$$\text{Catechin equivalents (mg/100g)} = \frac{St.conc\ C \times 50 \times T\ ext.680}{SW \times ST.\ ext.\ TA\ 578} \times 100$$

APPENDIX G

Determination of Phytate in Food Sample

(Modified Method from Hotz's, 2001)

Principle:

Base on Hotz's methods (2001), approximately 0.5 g of dried sample was extracted with 0.67 M HCl. The supernatant after centrifuged was removed and diluted with Millipore water and then percolated through strong anion exchange columns (Sep-pak (anion-exchange column), commercial columns). Innositol phosphates were eluted and evaporated to dryness, and the residue was diluted with 1 ml of Millipore water before determined using ion-pair reverse-phase chromatography.

Reagent:

1. Tetrabutylammonium hydroxide solution (TBNA) (Flika#86881)
2. Phosphoric acid 85% (Merck # 1.00573.1000)
3. Methanol (CH_3OH) (Baker analyzed #9070-68)
4. Sulfuric acid (NH_2SO_4) (Merck # 1.00731.2500)
5. Inositol hexaphhosphoric acid dodecasodium salt, from corn (P-8810, Sigma Chemical Co.)

Apparatus:

1. Vortex mixer (Model: G-560E, Scientific industries)
2. Centrifugation machine (Model: H-103 N series Kokusan enchinki Co.)
3. Sonicater (Model: 1510E-MT Bransonic)
4. Vacuum manifolds (Model: Vacuum manifold processing station, Agilent technologies)
5. Evaporator vacuum (Model: SpeedVac concentrator (SVC 100H), Savant instrument INC.)
6. HPLC system

7. Sep-pak,Vac 1cc. (100 mg) (water® Accell^{TM} Plus QMA cartridges Part No:WAT023620)

Procedure:

1. Approximately weigh 0.5 g of dried sample into test tube in duplicate.
2. Add 5 ml of 0.67 M HCl into each sample tube and homogenize by vortex mixer and sonicate in a bath for 30 minutes.
3. Centrifuge sample tubes at 3000 rpm for 10 minutes, then remove 2.5 ml of supernatant and dilute with 22.5 ml Millipore water.
4. Condition anion-exchange columns by adding 3 ml of 0.067 M HCl to sep-pak columns which is performed on vacuum manifolds and adjust flow rate to be 0.5-1 ml/min.
5. Add diluted samples (final volume about 25 ml) through the sep-pak column with folw rate 0.5-1 ml/min ; discard eluted.
6. Add 2 ml of 0.067 M HCl; discard eluted.
7. Elute with 4 ml 2 M HCl ; collect this fraction in test tube.
8. Eluants are evaporated to dryness in evaporator vacuum at 40°C.
9. The residue is dilute with 1 ml Millipore water and then sonicated for 10 minutes before injection into HPLC system.

Preparation of the Mobile Phase for HPLC system:

1. Add 1.1 ml phosphoric acid in 200 Millipore water.
2. Add 10 ml TBNOH in solution and then ad 300 ml methanol (CH_3OH), let cool at room temperature (total volume is 500 ml).
3. Adjust pH to 4.0 with 9N sulfuric acid (NH_2SO_4).
4. Filtrate the mobile phase by vacuum filtration through a 0.45 µm filter.

Preparation of the Standard Phytate:

Stock Standard:

Weigh Dodecasodium phytate 0.09238 g and then dilute with 10 ml of Millipore water.

Standard Dilution:

3.2 µmol/ml = 400µl of stock standard + 600 µl Millipore water

1.6 µmol/ml = 200 µl of stock standard + 800 µl Millipore water

0.8 µmol/ml = 100 µl of stock standard + 900 µl Millipore water

0.4 µmol/ml = 50 µl of stock standard + 950 µl Millipore water

Apparatus and Chromatographic Condition for HPLC system:

The HPLC system consists of pump equipped with a loop injector (515 HPLC pump water), ion-pair reverse-phase column (model: µ Bondapak C 18 type: 125A°, 10 µm, size: 3.9 mm × 300 mm), and a reflective index detector (model: varian series R13). The flow rate of the pump is 0.45 ml/min. The column is performed in a heater lock at 45°C.

Calculation:

The content of inositol phosphate (IP5 and IP6) is calculate in mg/100g of samples.

$$\text{Inositol phosphates (mg/100g)} = \frac{A \times B \times C \times D}{E \times F \times 10}$$

Where;

A = sample area

B = standard concentration (µmol/ml)

IP5 = $\frac{660.08}{580.1}$ × %peak area std. IP5 × 3.2

IP6 = %peak area std. IP5 × 3.2

C = Molecular weight of inositol phosphates (IP5 or IP6)

IP5 = 580.1

IP6 = 660.8

D = dilution factor

E = standard area (IP5 or IP6)

F = weigh of sample (g)

APPENDIX H

NUTRITION CHART OF 1 PORTION FOR THAI FRUITS

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
		Sodium = 2 mg (0.1 % Thai RDI) Potassium = 30 mg (1 % Thai RDI) Calcium = 4 mg (0% Thai RDI) Magnesium = 4 mg (1% Thai RDI)	Iron = 0.1 mg (1% Thai RDI) Copper = 0.06 mg (3% Thai RDI) Zinc = 0.1 mg (1% Thai RDI)	Polyphenol = 24.91 mg Tannin = 2.25 mg Catechin = 1.43 mg Phytate = 1.55 mg
Apple; Fuji variety *(Pyrus malus,* Borkh.)	**1 Small apple** 109 g with skin and core (102 g edible portion) (not peeled) Moisture = 86.8 g			

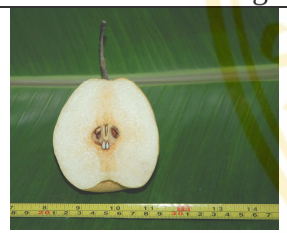
NUTRITION CHART OF 1 PORTION FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Apple**; Granny Smith variety *(Pyrus malus*, Borkh.)	 **1 Small apple** 120 g with skin and core (100 g edible portion) (peeled) Moisture = 86.0 g	Sodium = 2 mg (0.1 % Thai RDI) Potassium = 29 mg (1 % Thai RDI) Calcium = 5 mg (1 % Thai RDI) Magnesium = 4 mg (1 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.06 mg (3 % Thai RDI) Zinc = 0.0 mg (0 % Thai RDI)	Polyphenol = 90.24 mg Tannin = 1.76 mg Catechin = 0.79 mg Phytate = 1.69 mg
 **Banana** (ripe); Hawm variety *(Musa sp.)*	 **1/2 Medium banana** 73 g with skin (53 g edible portion) Moisture = 40.0 g	Sodium = 2 mg (0.1 % Thai RDI) Potassium = 184 mg (5 % Thai RDI) Calcium = 1 mg (0 % Thai RDI) Magnesium = 11 mg (3 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.06 mg (3 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 47.89 mg Tannin = 1.14 mg Catechin = 0.18 mg Phytate = 0.07 mg

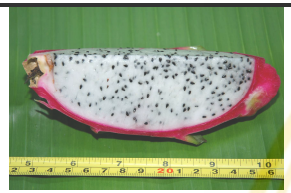
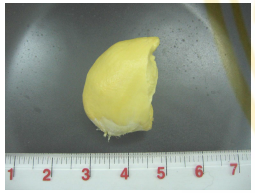
NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Banana** (ripe); Kai variety *(Musa sapientum;*Linn*)*	 **1 Large banana** 61 g with skin (48 g edible portion) Moisture = 34.4 g	Sodium = 3 mg (0.1 % Thai RDI) Potassium = 149 mg (4 % Thai RDI) Calcium = 1 mg (0 % Thai RDI) Magnesium = 11 mg (3 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.07 mg (4 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 44.87 mg Tannin = 2.51 mg Catechin = 0.61 mg Phytate = 0.21 mg
 **Banana** (ripe); Nahm-wah variety *(Musa sp.)*	 **1 Medium banana** 69 g with skin (53 g edible portion) Moisture = 35.5 g	Sodium = 3 mg (0.1 % Thai RDI) Potassium = 108 mg (3 % Thai RDI) Calcium = 3 mg (0 % Thai RDI) Magnesium = 13 mg (4 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.05 mg (2 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 50.93 mg Tannin = 7.10 mg Catechin = 2.46 mg Phytate = 0.21 mg

NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Chinese pear**; Hawm variety *(Pyrus communis)*	 **1 Large chinese pear** 165 g with skin and core (136 g edible portion) (not peeled) Moisture = 116.2 g	Sodium = 6 mg (0.3 % Thai RDI) Potassium = 55 mg (2 % Thai RDI) Calcium = 8 mg (1 % Thai RDI) Magnesium = 10 mg (3 % Thai RDI)	Iron = 0.3 mg (2 % Thai RDI) Copper = 0.11 mg (6 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 40.46 mg Tannin = 6.40 mg Catechin = 4.07 mg Phytate = 1.05 mg
 **Chinese pear**; Namphung *(Pyrus communis)*	 **1/2 Medium chinese pear** 177 g with skin and core (135 g edible portion) (peeled) Moisture = 116.4 g	Sodium = 5 mg (0.2 % Thai RDI) Potassium = 69 mg (2 % Thai RDI) Calcium = 2 mg (0 % Thai RDI) Magnesium = 8 mg (2 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.10 mg (5 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 19.76 mg Tannin = 2.44 mg Catechin = 2.49 mg Phytate = 1.23 mg

NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Dragon fruit**; Vietnam variety *(Hylocereus spp.)*	 **1/3 Dragon fruit** 170 g with skin (120 g edible portion) Moisture = 101.9 g	Sodium = 5 mg (0.2 % Thai RDI) Potassium = 325 mg (9 % Thai RDI) Calcium = 3 mg (0 % Thai RDI) Magnesium = 27 mg (8 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.07 mg (4 % Thai RDI) Zinc = 0.2 mg (1 % Thai RDI)	Polyphenol = 76.85 mg Tannin = 2.39 mg Catechin = 0.49 mg Phytate = 7.22 mg
 **Durian**; Chanee variety *(Durio spp.)*	 **1 Medium piece of durian** 77 g with seed (58 g edible portion) Moisture = 38.7 g	Sodium = 2 mg (0.1 % Thai RDI) Potassium = 235 mg (7 % Thai RDI) Calcium = 2 mg (0 % Thai RDI) Magnesium = 9 mg (3 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.13 mg (6 % Thai RDI) Zinc = 0.2 mg (1 % Thai RDI)	Polyphenol = 66.98 mg Tannin = 3.04 mg Catechin = 0.24 mg Phytate = ND*

NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Durian**; Mawntong variety *(Durio spp.)*	 **1 Medium piece of durian** 60 g with seed (50 g edible portion) Moisture = 31.2 g	Sodium = 1 mg (0 % Thai RDI) Potassium = 145 mg (4 % Thai RDI) Calcium = 2 mg (0 % Thai RDI) Magnesium = 10 mg (3 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.10 mg (5 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 88.01 mg Tannin = 2.42 mg Catechin = 0.11 mg Phytate = ND*
 **Grape**; Green variety *(Vitis vinifera,* L.*)*	 **15 Grapes** 98 g with seeds (93 g edible portion) Moisture = 77.1 g	Sodium = 6 mg (0.2 % Thai RDI) Potassium = 116 mg (3 % Thai RDI) Calcium = 6 mg (1 % Thai RDI) Magnesium = 5 mg (1 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.26 mg (13 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 72.06 mg Tannin = 5.83 mg Catechin = 1.80 mg Phytate = 0.58 mg

NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Guava**; Pan-seetong variety *(Psidium guajava)*	 **1/3 Medium guava** (123 g edible portion) Moisture = 107.6 g	Sodium = 7 mg (0.3 % Thai RDI) Potassium = 258 mg (7 % Thai RDI) Calcium = 4 mg (0 % Thai RDI) Magnesium = 7 mg (2 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.11 mg (6 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 132.56 mg Tannin = 8.69 mg Catechin = 1.42 mg Phytate = 3.01 mg
 **Jackfruit** *(Artocapus heterophylla)*	 **2 Pieces of jackfruit** (61 g edible portion) Moisture = 45.2 g	Sodium = 3 mg (0.1 % Thai RDI) Potassium = 126 mg (4 % Thai RDI) Calcium = 6 mg (1 % Thai RDI) Magnesium = 12 mg (3 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.12 mg (6 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 28.80 mg Tannin = 0.51 mg Catechin = 0.07 mg Phytate = 0.76 mg

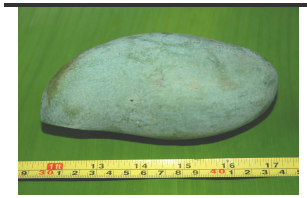
NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Longan**; Kalokbew variety *(Euphoria longana*, Lamk*)*.	 **12 Longans** 131 g with skin and seed (86 g edible portion) Moisture = 68.7 g	Sodium = 9 mg (0.4 % Thai RDI) Potassium = 90 mg (3 % Thai RDI) Calcium = 6 mg (1 % Thai RDI) Magnesium = 7 mg (2 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.12 mg (6 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 86.03 mg Tannin = 4.76 mg Catechin = 0.13 mg Phytate = 0.10 mg
 **Longkong** *(Lansium domesticum* Corr*)*	 **5 Large longkongs** 150 g with skin and seeds (94 g edible portion) Moisture = 75.9 g	Sodium = 3 mg (0.1 % Thai RDI) Potassium = 180 mg (5 % Thai RDI) Calcium = 7 mg (1 % Thai RDI) Magnesium = 12 mg (3 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.11 mg (6 % Thai RDI) Zinc = 0.2 mg (1 % Thai RDI)	Polyphenol = 34.53 mg Tannin = 0.86 mg Catechin = 1.40 mg Phytate = 3.03 mg

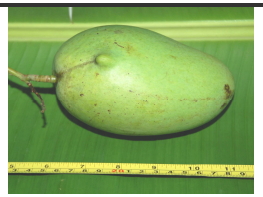
NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Lychee**; Hohnghooway variety *(Litchi chinensis*, Sonn.*)*	 **6 Large lychees** 151 g with skin and seeds (98 g edible portion) Moisture = 79.7 g	Sodium = 3 mg (0.1 % Thai RDI) Potassium = 129 mg (4 % Thai RDI) Calcium = 2 mg (0 % Thai RDI) Magnesium = 10 mg (3 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.19 mg (10 % Thai RDI) Zinc = 0.2 mg (1 % Thai RDI)	Polyphenol = 109.59 mg Tannin = 5.77 mg Catechin = 1.74 mg Phytate = 1.81 mg
 **Lychee**; Jackkrapat variety *(Litchi chinensis*, Sonn.*)*	 **4 Large lychees** 121 g with skin and seeds (78 g edible portion) Moisture = 64.5 g	Sodium = 2 mg (0.1 % Thai RDI) Potassium = 129 mg (4 % Thai RDI) Calcium = 2 mg (0 % Thai RDI) Magnesium = 7 mg (2 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.08 mg (4 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 91.55 mg Tannin = 10.05 mg Catechin = 6.96 mg Phytate = 3.35 mg

NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Mango** (unripe); Kheosawoei variety *(Mangifera indica)*	 **1/2 Medium unripe mango** 86 g with skin (75 g edible portion) Moisture = 59.5 g	Sodium = 0 mg (0 % Thai RDI) Potassium = 68 mg (2 % Thai RDI) Calcium = 4 mg (0 % Thai RDI) Magnesium = 7 mg (2 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.09 mg (4 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 49.13 mg Tannin = 11.58 mg Catechin = ND* Phytate = 0.19 mg
 **Mango** (ripe); Nahmdawgmai variety *(Mangifera indica)*	 **1/2 Medium ripe mango** 90 g with skin (79 g edible portion) Moisture = 63.2 g	Sodium = 2 mg (0.1 % Thai RDI) Potassium = 64 mg (2 % Thai RDI) Calcium = 4 mg (0 % Thai RDI) Magnesium = 7 mg (2 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.06 mg (3 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 62.60 mg Tannin = 25.60 mg Catechin = 0.60 mg Phytate = 0.09 mg

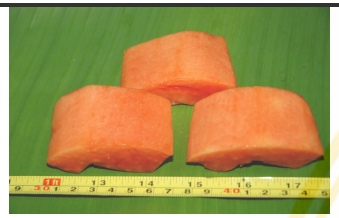
NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Mango** (unripe); Rad variety *(Mangifera indica)*	 **1/2 Medium unripe mango** 88 g with skin (76 g edible portion) Moisture = 62.6 g	Sodium = 3 mg (0.1 % Thai RDI) Potassium = 80 mg (2 % Thai RDI) Calcium = 6 mg (1 % Thai RDI) Magnesium = 6 mg (2 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.12 mg (6 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 61.91 mg Tannin = 10.50 mg Catechin = 0.09 mg Phytate = 0.16 mg
 **Mangosteen** *(Garcinia mangostana)*	 **4 Medium mangosteens** 244 g with skin and seeds (77 g edible portion) Moisture = 61.6 g	Sodium = 2 mg (0.1 % Thai RDI) Potassium = 24 mg (1 % Thai RDI) Calcium =6 mg (1 % Thai RDI) Magnesium = 9 mg (3 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.07 mg (4 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 66.91 mg Tannin = 0.91 mg Catechin = ND* Phytate = 0.19 mg

NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Orange**; Clementine variety *(Citrus sinesis* Osb.*)*	 **1 Medium orange** 191 g with skin and seeds (101 g edible portion) Moisture = 88.5 g	Sodium = 2 mg (0.1 % Thai RDI) Potassium = 84 mg (2 % Thai RDI) Calcium = 17 mg (2 % Thai RDI) Magnesium = 9 mg (3 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.07 mg (4 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 61.78 mg Tannin = 1.26 mg Catechin = 0.16 mg Phytate = 0.68 mg
 **Orange**; Sai-nuhm-phung variety *(Citrus sinesis* Osb.*)*	 **1 Large orange** 155 g with skin and seeds (122 g edible portion) Moisture = 104.6 g	Sodium = 7 mg (0.3 % Thai RDI) Potassium = 279 mg (8 % Thai RDI) Calcium = 18 mg (2 % Thai RDI) Magnesium = 9 mg (3 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.06 mg (3 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 81.90 mg Tannin = 0.84 mg Catechin = 0.04 mg Phytate = 1.00 mg

NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Papaya** (ripe); Khak-dahm variety *(Carica papaya,* Linn.*)*	 **3 Large pieces or 6 edible pieces of ripe papaya** (130 g edible portion) Moisture = 116.5 g	Sodium = 4 mg (0.2 % Thai RDI) Potassium = 258 mg (7 % Thai RDI) Calcium = 10 mg (1 % Thai RDI) Magnesium = 9 mg (3 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.05 mg (2 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 6.07 mg Tannin = 1.98 mg Catechin = ND* Phytate = ND*
 **Pineapple**; Sri-ra-cha variety *(Ananas comosus,* Merr.*)*	 **1/6 Pineapple** (101 g edible portion) Moisture = 85.7 g	Sodium = 4 mg (0.2 % Thai RDI) Potassium = 62 mg (2 % Thai RDI) Calcium = 10 mg (1 % Thai RDI) Magnesium = 10 mg (3 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.05 mg (2 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 50.84 mg Tannin = 0.71 mg Catechin = 0.09 mg Phytate = ND*

NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Pomelo**; Khao-nahm-phung variety *(Citrus maxima,* Merr.*)*	 **1 Large pulp of pomelo** (92 g edible portion) Moisture = 81.5 g	Sodium = 7 mg (0.3 % Thai RDI) Potassium = 73 mg (2 % Thai RDI) Calcium = 7 mg (1 % Thai RDI) Magnesium = 4 mg (1 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.05 mg (2 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 34.84 mg Tannin = 0.58 mg Catechin = 0.19 mg Phytate = 0.73 mg
 **Pomelo**; Tongdee variety *(Citrus maxima,* Merr.*)*	 **2 Medium pulps of pomelo** (125 g edible portion) Moisture = 111.0 g	Sodium = 10 mg (0.4 % Thai RDI) Potassium = 114 mg (3 % Thai RDI) Calcium = 12 mg (1 % Thai RDI) Magnesium = 8 mg (2 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.06 mg (3 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 40.73 mg Tannin = 0.78 mg Catechin = 0.07 mg Phytate = 2.50 mg

NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Rambutan**; Rong-rean variety *(Nephelium lappaceum*, Linn.*)*	 **5 Medium rambutans** 165 g with skin and seeds (75 g edible portion) Moisture = 60.4 g	Sodium = 2 mg (0.1 % Thai RDI) Potassium = 58 mg (2 % Thai RDI) Calcium = 6 mg (1 % Thai RDI) Magnesium = 7 mg (2 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.12 mg (6 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 50.54 mg Tannin = 2.16 mg Catechin = 0.79 mg Phytate = 1.53 mg
 **Rose apple**; Toon-klow variety *(Syzygium samarangense)*	 **3 Small rose apples** 228 g with seeds (205 g edible portion) Moisture = 186.6 g	Sodium = 9 mg (0.4 % Thai RDI) Potassium = 126 mg (4 % Thai RDI) Calcium = 4 mg (0 % Thai RDI) Magnesium = 13 mg (4 % Thai RDI)	Iron = 0.3 mg (2 % Thai RDI) Copper = 0.10 mg (5 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 49.96 mg Tannin = 8.10 mg Catechin = 1.47 mg Phytate = ND*

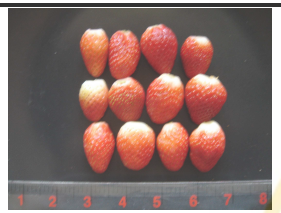
NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Rose apple**; Tup-tim-jun variety *(Syzygium samarangense)*	 **2 Small rose apples** 175 g with seeds (152 g edible portion) Moisture = 134.9 g	Sodium = 9 mg (0.4 % Thai RDI) Potassium = 161 mg (5 % Thai RDI) Calcium = 2 mg (0 % Thai RDI) Magnesium = 10 mg (3 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.07 mg (4 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 29.90 mg Tannin = 5.26 mg Catechin = 0.72 mg Phytate = 0.02 mg
 **Salacca** *(Salacca sp.)*	 **5 Salaccas** 166 g with skin and seeds (78 g edible portion) Moisture = 62.8 g	Sodium = 4 mg (0.2 % Thai RDI) Potassium = 89 mg (3 % Thai RDI) Calcium = 3 mg (0 % Thai RDI) Magnesium = 7 mg (2 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.06 mg (3 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 55.63 mg Tannin = 1.63 mg Catechin = 0.29 mg Phytate = ND*

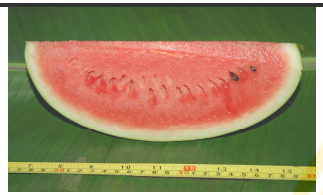
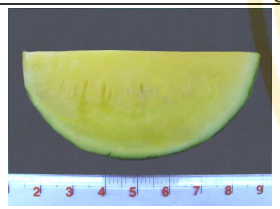
NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Sapodilla** *(Achras sapota,* L.*)*	 **1 Medium sapodilla** 89 g with skin and seeds (69 g edible portion) (peeled) Moisture = 52.4 g	Sodium = 11 mg (0.5 % Thai RDI) Potassium = 88 mg (3 % Thai RDI) Calcium = 10 mg (1 % Thai RDI) Magnesium = 7 mg (2 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.03 mg (2 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 39.76 mg Tannin = 18.15 mg Catechin = 7.81 mg Phytate = 1.04 mg
 **Star fruit** *(Averrhoa carambola)*	 **5 Pieces of star fruit** (159 g edible portion) Moisture = 141.6 g	Sodium = 5 mg (0.2 % Thai RDI) Potassium = 118 mg (3 % Thai RDI) Calcium = 2 mg (0 % Thai RDI) Magnesium = 11 mg (3 % Thai RDI)	Iron = 0.3 mg (2 % Thai RDI) Copper = 0.08 mg (4% Thai RDI) Zinc = 0.3 mg (2 % Thai RDI)	Polyphenol = 235.91 mg Tannin = 14.56 mg Catechin = 12.79 mg Phytate = 0.51 mg

NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Strawberry** *(Fragaria spp.)*	 **12 Large strawberries** 196 g with pole (180 g edible portion) Moisture = 161.2 g	Sodium = 6 mg (0.2 % Thai RDI) Potassium = 238 mg (7 % Thai RDI) Calcium = 21 mg (3 % Thai RDI) Magnesium = 19 mg (5 % Thai RDI)	Iron = 0.6 mg (4 % Thai RDI) Copper = 0.11 mg (6 % Thai RDI) Zinc = 0.3 mg (2 % Thai RDI)	Polyphenol = 397.13 mg Tannin = 28.49 mg Catechin = ND* Phytate = 3.87 mg
 **Sugar apple**; Nahng variety *(Auona sguamosa)*	 **1/2 Medium sugar apple** 109 g with skin and seeds (57 g edible portion) Moisture = 42.2 g	Sodium = 0 mg (0 % Thai RDI) Potassium = 122 mg (3 % Thai RDI) Calcium = 9 mg (1 % Thai RDI) Magnesium = 12 mg (3 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.06 mg (3 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 183.90 mg Tannin = 24.72 mg Catechin = 12.22 mg Phytate = ND*

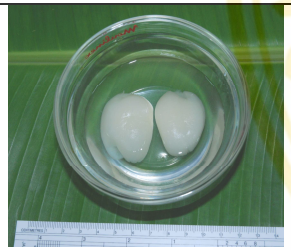
NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Watermelon** (red); Jin-trarah variety *(Citruluss vulgalis*, Schrad.*)*	 **1/8 Medium red watermelon** 315 g with skin and seeds (170 g edible portion) Moisture = 151.1 g	Sodium = 9 mg (0.4 % Thai RDI) Potassium = 204 mg (6 % Thai RDI) Calcium = 11 mg (1 % Thai RDI) Magnesium = 14 mg (4 % Thai RDI)	Iron = 0.3 mg (2 % Thai RDI) Copper = 0.11 mg (6 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 47.94 mg Tannin = 1.54 mg Catechin = 0.03 mg Phytate = ND*
 **Watermelon** (yellow); Jin-trarah variety *(Citruluss vulgalis*, Schrad.*)*	 **1/8 Medium yellow watermelon** 316 g with skin and seeds (188 g edible portion) Moisture = 171.7 g	Sodium = 6 mg (0.2 % Thai RDI) Potassium = 209 mg (6 % Thai RDI) Calcium = 16 mg (2 % Thai RDI) Magnesium = 14 mg (4 % Thai RDI)	Iron = 0.3 mg (2 % Thai RDI) Copper = 0.10 mg (5 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 44.07 mg Tannin = 11.64 mg Catechin = 0.02 mg Phytate = 0.39 mg

NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant Contents
 **Fruit salad** or **Fruit cocktail**	 **3 Tablespoons of fruits salad and 4 tablespoons of syrup** (91 g edible portion) Moisture = 72.0 g	Sodium = 3 mg (0.1 % Thai RDI) Potassium = 73 mg (2 % Thai RDI) Calcium = 9 mg (1 % Thai RDI) Magnesium = 6 mg (2 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.05 mg (2 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 35.49 mg Tannin = 12.54 mg Catechin = ND*
 **Longan in syrup**	 **4 Longans and 3 1/2 tablespoons of syrup** (71 g edible portion) Moisture = 56.1 g	Sodium = 1 mg (0 % Thai RDI) Potassium = 39 mg (1 % Thai RDI) Calcium = 16 mg (2 % Thai RDI) Magnesium = 2 mg (1 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.06 mg (3 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 19.70 mg Tannin = 11.82 mg Catechin = ND*

NUTRITION CHART FOR THAI FRUITS, *(Continued)*

Fruit	One portion	Macro-minerals	Micro-minerals	Antioxidant contents
 **Lychee in syrup**	 **2 Lychees and 3 1/2 tablespoons of syrup** (70 g edible portion) Moisture = 54.1 g	Sodium = 6 mg (0.2 % Thai RDI) Potassium = 53 mg (2 % Thai RDI) Calcium = 6 mg (1 % Thai RDI) Magnesium = 3 mg (1 % Thai RDI)	Iron = 0.2 mg (1 % Thai RDI) Copper = 0.07 mg (4 % Thai RDI) Zinc = 0.1 mg (1 % Thai RDI)	Polyphenol = 28.67 mg Tannin = 11.75 mg Catechin = ND*
 **Rambutan in syrup**	 **2 Rambutans and 3 tablespoons of syrup** (63 g edible portion) Moisture = 50.0 g	Sodium = 4 mg (0.2 % Thai RDI) Potassium = 18 mg (1 % Thai RDI) Calcium = 13 mg (2 % Thai RDI) Magnesium = 3 mg (1 % Thai RDI)	Iron = 0.1 mg (1 % Thai RDI) Copper = 0.05 mg (2 % Thai RDI) Zinc = 0.0 mg (0 % Thai RDI)	Polyphenol = 15.12 mg Tannin = 9.87 mg Catechin = ND*

* ND = Not detectable

BIOGRAPHY

NAME Miss. Chaninneat Torsahakul

DATE OF BIRTH 6 Dec 1981

PLACE OF BIRTH Bangkok, Thailand

INSTITUTIONS ATTENDED Thammasart University, 2000 :
Bachelor of Science
(Science Technology)
Mahidol University, 2004 :
Master of Science
(Nutrition)

HOME ADDRESS 29 Soi Ramkhamhaeng 8,
Ramkhamhaeng Rd., Huamark,
Bangkapi, Bangkok 10240
E-mail: chaninneat@hotmail.com