A STUDY ON PHYSICOCHEMICAL CHARACTERISTICS
OF PIGMENTED TRADITIONAL
SABAH RICE VARIETIES

CHONG KHAII YENG

DEPARTMENT
UNIVERSITY MALAYSIA SABAH

DISSEETATION SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF BACHELOR OF
AGRICULTURE SCIENCE WITH HONOURS

HORTICULTURE AND LANDSCAPE PROGRAMME
FACULTY OF SUSTAINABLE AGRICULTURE
UNIVERSITY MALAYSIA SABAH
2015
UNIVERSITI MALAYSIA SABAH
BORANG PENGESAHAN TESIS

JUDUL: A STUDY ON PHYSICOCHEMICAL CHARACTERISTICS OF PIGMENTED TRADITIONAL SABAH RICE VARIETIES

IJAZAH: B. Sc. (Hons) Agricultural Science (Horticulture and Landscape)

SAYA: CHONG KHAH YEANG
(HURUF BESAR)

Mengaku membenarkan tesis *(LPSM/Sarjana/Doktor Falsafah) Ini disimpan di Perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:-

1. Tesis adalah hak milik Universiti Malaysia Sabah.
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (/)

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di AKTA RAHSIA RASMI 1972)

☑ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

☐ TIDAK TERHAD

Disahkan oleh:

SIGNATURE

(TANDATANGAN PUSTAKAWAN)

Alamat Tetap: 150, Lorong 4,
Kampung Baru Lumut,
34000 Tapin, Perak

TARIKH: 13 Feb 2015

Prof. Datin Dr. Mariam ABD LATIF

(NAMA PENYELIA)

(TANDATANGAN PENULIS)

Catatan:
* Potong yang tidak berkenaan.
* Jika tesis Ini SULIT dan TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT dan TERHAD.
* Tesis dimaksudkan sebagai tesis bagi ijazah Doktor Falsafah dan Sarjana Secara Penyelidikan atau disertai bagi pengajian secara kerja kursus dan Laporan Proyek Sarjana Muda (LPSM).
DECLARATION

I hereby declare that this dissertation is based on my original work except for citations and quotations which have been duly acknowledged. I also declared that no part of this dissertation has been previously or concurrently submitted for a degree at this or any other university.

Chong Khai Yeng
BR11110016
1 DECEMBER 2014
VERIFIED BY

1. Prof. Datin Dr. Mariam Abd, Latip
   SUPERVISOR
   
2. Assc. Prof. Dr. Azwan Awang
   EXAMINER 1
   
3. Assc. Prof. Dr. Harpal Singh Saini
   
4. Prof. Dr. Wan Mohamad Wan Othman
   DEAN OF FSA
ACKNOWLEDGEMENT

I would like to express my sincere and utmost gratitude to my supervisor, Prof. Datin. Dr. Mariam Abd. Latip for her supervision and guidance towards the completion of this dissertation. I would like to thank her for the suggestions and help that she has given to me in the entire process. Also, I am truly grateful that despite off work hours, she was willing to edit and suggest more appropriate methods of writing. I also appreciate that she checked on my progress and made sure that I did not go astray.

Next, I would like to thank Ms. Chee Fong Tyng for providing the rice samples for this study. Also I thanked her for sharing methods of analysis to me when I was stuck at some point of the study. In addition, I would like to also thank Dr. Mohamadu Boyie Jalloh for assisting me in my statistical analysis. I would also like to thank my two examiners, Dr. Azwan Awang and Dr. Harpal Singh Saini for their constructive comments during FYP 1.

I would also like to thank Tracy Ong for letting me stay at her place when I was in Kota Kinabalu carrying out a part of this study. Without her, I would not have been able to complete the mineral content analysis.

Also, I would like to express my sincere gratitude to staffs and lab assistants of Faculty of Sustainable Agriculture and Faculty of Science and Natural Resources for their assistance in completing this study. Also to Faculty of Sustainable Agriculture, I would like to thank the faculty for providing laboratory materials, chemicals, machines and services needed in this study.

I hereby would also like to thank all my friends who have helped out in completing this study. I could have done it without their help as well. Thanks to their constant support and also constructive opinions, I was able to improve on this dissertation. Last but not least, I would like to thank my family members for their constant support emotionally from home.
ABSTRACT

A study was conducted to determine the physicochemical traits of traditional Sabah rice. Nine pigmented and one white rice varieties were evaluated. Parameters that were screened were amylose content (AC), rice gelatinization temperature (GT), rice gel consistency (GC) and mineral content of rice (MC). Physical characterization such as length, breadth, length/breadth (L/B) ratio and kernel elongation ratio (KER) were measured to determine the length class and shape class of grains. There was a negative correlation between L/B ratio and KER (r= -0.357, p<0.05). From amylose content analysis, the preferred variety that has low amylose content was Gongdokan 12/45 (4.5%) which gives a soft texture when cooked is desired by consumers. Through alkali spread value analysis, the preferred variety identified was Gaur 12/46 which had significantly lowest gelatinization temperature with a score of 6 among the other rice varieties which only scored 2 to 3. Low gelatinization temperature requires less cooking time which is desired by consumers. Rice gel consistency analysis, the preferred variety detected was Baragang 12/14 (59.400 mm±3.361) which had the hardest gel among the traditional rice varieties analysed. Hard rice gel consistency variety is not sticky when cooked. Consumers prefer intermediate rice gel consistency varieties. There was no significant correlation between rice amylose content, rice gelatinization temperature and rice gel consistency. From mineral content analysis, the most abundant mineral found in the rice varieties are potassium (K) which was highest in Taragong 13/09 (125.84 ppm), magnesium (Mg) which was highest in Tadong 12/51 (46.89 ppm) and calcium (Ca) which was highest in Purak 12/16 (4.43 ppm). There is no preferred variety that was preferred in all mineral elements.
KAJIAN KE ATAS CIRI-CIRI FIZIKOKIMIA VARIETI PADI TRADISIONAL YANG BERPIGMEN DI SABAH

ABSTRAK

Satu kajian telah dijalankan untuk menentukan ciri-ciri fizikokimia beras tradisional Sabah. Sembilan jenis beras berpigmen dan sejenis beras putih telah dinilai. Parameter yang dikaji adalah kandungan amilosa (AC), suhu penggelatinan beras (GT), gel konsisten beras (GC) dan kandungan mineral beras (MC). Pencirian fizikal seperti panjang, lebar, nisbah panjang/lebar (L/B) dan nisbah pemanjangan kernel (KER) diukur untuk menentukan kelas panjang dan bentuk bijirin. Terdapat hubungan yang negatif antara nisbah L/B dan KER (r = -0.357, p <0.05). Dari analisis kandungan amilosa, varieti unggul yang mempunyai kandungan amilosa yang rendah adalah Gongdokan 12/45 (4.5%) yang memberikan tekstur yang lembut apabila dimasak mengikut kehendak pengguna. Melalui analisis nilai alkali kembangan, varieti unggul yang dikenal pasti adalah Gaur 12/46 yang mempunyai suhu penggelatinan yang paling rendah antara varieti beras yang dikaji dengan skor enam berbanding varieti lain yang mendapat skor 2 hingga 3. Suhu penggelatinan rendah memerlukan masa memasak singkat seperti yang dikehendaki oleh pengguna. Dari analisis gel konsisten beras, varieti unggul dikesan adalah Baragang 12/14 (59.400 mm±3.361) yang mempunyai gel yang paling lembut di antara varieti padi tradisional dianalisis. Beras gel konsisten lembut tidak mengeraskan selepas penyejukan. Pengguna lebih suka beras jenis gel lembut konsisten. Tiada hubungan yang signifikan antara kandungan amilosa beras, suhu penggelatinan beras dan gel konsisten beras. Dari analisis kandungan mineral, mineral yang paling banyak ditemui dalam varieti beras adalah kalium (K) yang mana tertinggi dalam Taragong 13/09 (125,84 ppm), magnesium (Mg) yang mana tertinggi dalam Tadong 12/51 (46.89 ppm) dan kalsium (Ca) yang mana tertinggi dalam Purak 12/16 (4.43 ppm). Tidak ada varieti unggul yang unggul dalam semua unsur-unsur mineral.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Content</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECLARATION</td>
<td>i</td>
</tr>
<tr>
<td>VERIFICATION</td>
<td>ii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENT</td>
<td>iii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>iv</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td>v</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>viii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>ix</td>
</tr>
<tr>
<td>LIST OF FORMULAE</td>
<td>xi</td>
</tr>
<tr>
<td>LIST OF SYMBOLS, UNITS AND ABBREVIATIONS</td>
<td>xi</td>
</tr>
</tbody>
</table>

## CHAPTER 1 INTRODUCTION

1.1 Introduction

1.2 Objectives

1.3 Justification

1.4 Significance of Study

1.5 Hypothesis

## CHAPTER 2 LITERATURE REVIEW

2.1 *Oryza sativa*

2.1.1 Distribution

2.1.2 Edible Part and Uses

2.1.3 Botany

2.2 White Rice

2.3 Pigmented Rice

2.4 Benefits of Pigmented Rice

2.4.1 Mineral Content

2.4.2 Antioxidant Activity in Pigmented Rice

2.4.3 Anticancer Activity

2.4.4 Anti Atherosclerotic Activity

2.4.5 Cardioprotective Activity

2.4.6 Hepaprotective Activity

2.4.7 Antianaphylactic/Antiallergic Activity

2.4.8 Traditional Medicinal Uses

2.5 Grain Eating and Cooking Quality

2.5.1 Amylose Content

2.5.2 Gelatinization Temperature

2.5.3 Gel consistency

2.6 Morphological Characteristics of Rice

## CHAPTER 3 MATERIALS AND METHODS

3.1 Materials

3.2 Physical Characterization

3.2.1 Kernel Length

3.2.2 Kernel Breadth

3.2.3 Kernel Elongation Ratio

3.3 Chemical Characterization
3.3.1 Amylose Content (AC) Analysis
3.3.2 Alkali Spread Value (ASV) Analysis
3.3.3 Rice Gel Consistency Analysis
3.3.4 Rice Mineral Content Analysis
3.4 Data Analysis

CHAPTER 4 RESULTS
4.1 Introduction
4.2 Physical Characterisation
   4.2.1 Kernel Length and Breadth
   4.2.2 Kernel Elongation Ratio (KER)
   4.2.3 Correlation between Length/Breadth (L/B) Ratio and KER
4.3 Chemical Characterisation
   4.3.1 Rice Amylose Content (AC)
   4.3.2 Rice Gelatinization Temperature (GT)
   4.3.3 Rice Gel Consistency (GC)
   4.3.4 Correlation between Rice Amylose Content, Rice Gelatinization Temperature and Rice Gel Consistency
   4.3.5 Correlation between Physical Characteristics and Chemical Characteristics
   4.3.6 Mineral Content

CHAPTER 5 DISCUSSION
5.1 Physical Characteristic
   5.1.1 Kernel Elongation Ratio
   5.1.2 Correlation between Length/Breadth (L/B) Ratio and Kernel Elongation Ratio (KER)
5.2 Chemical Characteristics
   5.2.1 Rice Amylose Content (AC)
   5.2.2 Rice Gelatinization Temperature (GT)
   5.2.3 Rice Gel Consistency (GC)
   5.2.4 Correlation between Rice Amylose Content, Rice Gelatinization Temperature and Rice Gel Consistency
   5.2.5 Correlation between Physical Characteristics and Chemical Characteristics
   5.2.6 Mineral Content in Rice

CHAPTER 6 CONCLUSION
6.1 Conclusion
6.2 Recommendations
   6.2.1 Future Study on Physiochemical Characteristic of Pigmented Traditional Sabah Rice Variety

REFERENCES
APPENDICES
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Size classification of rice grain</td>
<td>14</td>
</tr>
<tr>
<td>2.2</td>
<td>Shape classification of rice grain</td>
<td>14</td>
</tr>
<tr>
<td>3.1</td>
<td>Traditional rice varieties used and their origin</td>
<td>15</td>
</tr>
<tr>
<td>3.2</td>
<td>Size classification</td>
<td>21</td>
</tr>
<tr>
<td>3.3</td>
<td>Shape classification</td>
<td>21</td>
</tr>
<tr>
<td>3.4</td>
<td>Numerical scale for scoring gelatinization temperature</td>
<td>23</td>
</tr>
<tr>
<td>4.1</td>
<td>Physical characterisation of 10 traditional rice in Sabah</td>
<td>27</td>
</tr>
<tr>
<td>4.2</td>
<td>Kernel elongation ratio (KER) of 10 traditional rice in Sabah</td>
<td>29</td>
</tr>
<tr>
<td>4.3</td>
<td>Amylose content in percentage and category of 10 traditional rice varieties</td>
<td>31</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td>------</td>
</tr>
<tr>
<td>2.1</td>
<td>Ripening padi in lowland padi field</td>
<td>7</td>
</tr>
<tr>
<td>2.2</td>
<td>Padi plants with ripe harvestable ears</td>
<td>7</td>
</tr>
<tr>
<td>2.3</td>
<td>Close-up of ripening padi</td>
<td>7</td>
</tr>
<tr>
<td>2.4</td>
<td>Harvested ripe padi ears</td>
<td>8</td>
</tr>
<tr>
<td>3.1</td>
<td>Variety Tadong 12/51</td>
<td>16</td>
</tr>
<tr>
<td>3.2</td>
<td>Variety Tadong 13/12</td>
<td>16</td>
</tr>
<tr>
<td>3.3</td>
<td>Variety Tadong 14/04</td>
<td>17</td>
</tr>
<tr>
<td>3.4</td>
<td>Variety Gaur 12/46</td>
<td>17</td>
</tr>
<tr>
<td>3.5</td>
<td>Variety Tenghilan 12/44</td>
<td>18</td>
</tr>
<tr>
<td>3.6</td>
<td>Variety Merah 12/28</td>
<td>18</td>
</tr>
<tr>
<td>3.7</td>
<td>Variety Baragang 12/14</td>
<td>19</td>
</tr>
<tr>
<td>3.8</td>
<td>Variety Gongdokan 12/45</td>
<td>19</td>
</tr>
<tr>
<td>3.9</td>
<td>Variety Taragong 13/09</td>
<td>20</td>
</tr>
<tr>
<td>3.10</td>
<td>Variety Purak 12/16</td>
<td>20</td>
</tr>
<tr>
<td>3.1</td>
<td>Typical gel consistency values of milled rice.</td>
<td>20</td>
</tr>
<tr>
<td>4.1</td>
<td>Ten traditional Sabah rice varieties</td>
<td>28</td>
</tr>
<tr>
<td>4.2</td>
<td>Amylose content in (mean±standard deviation) of 10 traditional rice in Sabah</td>
<td>30</td>
</tr>
<tr>
<td>4.3</td>
<td>Comparison of studied rice variety to potato amylose content standard curve</td>
<td>32</td>
</tr>
<tr>
<td>4.4</td>
<td>Score of gelatinization temperature for 10 traditional rice in Sabah</td>
<td>33</td>
</tr>
<tr>
<td>4.5</td>
<td>Gel length in millimeter (mm) of 10 traditional rice in Sabah</td>
<td>34</td>
</tr>
</tbody>
</table>

continued ...
<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.6</td>
<td>Content of barium (Ba) in ppm of 10 traditional rice in Sabah</td>
<td>37</td>
</tr>
<tr>
<td>4.7</td>
<td>Content of calcium (Ca) in ppm of 10 traditional rice in Sabah</td>
<td>38</td>
</tr>
<tr>
<td>4.8</td>
<td>Content of cobalt (Co) in ppm of 10 traditional rice in Sabah</td>
<td>39</td>
</tr>
<tr>
<td>4.9</td>
<td>Content of chromium (Cr) in ppm of 10 traditional rice in Sabah</td>
<td>40</td>
</tr>
<tr>
<td>4.10</td>
<td>Content of copper (Cu) in ppm of 10 traditional rice in Sabah</td>
<td>41</td>
</tr>
<tr>
<td>4.11</td>
<td>Content of iron (Fe) in ppm of 10 traditional rice in Sabah</td>
<td>42</td>
</tr>
<tr>
<td>4.12</td>
<td>Content of indium (In) in ppm of 10 traditional rice in Sabah</td>
<td>43</td>
</tr>
<tr>
<td>4.13</td>
<td>Content of potassium (K) in ppm of 10 traditional rice in Sabah</td>
<td>44</td>
</tr>
<tr>
<td>4.14</td>
<td>Content of magnesium (Mg) in ppm of 10 traditional rice in Sabah</td>
<td>45</td>
</tr>
<tr>
<td>4.15</td>
<td>Content of manganese (Mn) in ppm of 10 traditional rice in Sabah</td>
<td>46</td>
</tr>
<tr>
<td>4.16</td>
<td>Content of nickel (Ni) in ppm of 10 traditional rice in Sabah</td>
<td>47</td>
</tr>
<tr>
<td>4.17</td>
<td>Content of sodium (Na) in ppm of 10 traditional rice in Sabah</td>
<td>48</td>
</tr>
<tr>
<td>4.18</td>
<td>Content of rubidium (Rb) in ppm of 10 traditional rice in Sabah</td>
<td>49</td>
</tr>
<tr>
<td>4.19</td>
<td>Content of selenium (Se) in ppm of 10 traditional rice in Sabah</td>
<td>50</td>
</tr>
<tr>
<td>4.20</td>
<td>Content of strontium (Sr) in ppm of 10 traditional rice in Sabah</td>
<td>51</td>
</tr>
<tr>
<td>4.21</td>
<td>Content of thallium (Tl) in ppm of 10 traditional rice in Sabah</td>
<td>52</td>
</tr>
<tr>
<td>4.22</td>
<td>Content of vanadium (V) in ppm of 10 traditional rice in Sabah</td>
<td>53</td>
</tr>
<tr>
<td>4.23</td>
<td>Content of zinc (Zn) in ppm of 10 traditional rice in Sabah</td>
<td>54</td>
</tr>
</tbody>
</table>
### LIST OF FORMULAE

<table>
<thead>
<tr>
<th>Formulae</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 Kernel Elongation Ratio</td>
<td>22</td>
</tr>
<tr>
<td>[ KER = \frac{\text{Length of cooked rice (Lf)}}{\text{Length of raw rice (Lo)}} ]</td>
<td></td>
</tr>
<tr>
<td>3.2 Amylose Content Percentage (%)</td>
<td>23</td>
</tr>
<tr>
<td>[ % = 100 \times \text{Antilog}(-A) ]</td>
<td></td>
</tr>
<tr>
<td>[ A = \text{Absorbance Unit} ]</td>
<td></td>
</tr>
</tbody>
</table>

### LIST OF SYMBOLS, UNITS AND ABBREVIATIONS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>Amylose Content</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
</tr>
<tr>
<td>ASV</td>
<td>Alkali Spread Value</td>
</tr>
<tr>
<td>C₂H₅O</td>
<td>Ethanol</td>
</tr>
<tr>
<td>GC</td>
<td>Gel Consistency</td>
</tr>
<tr>
<td>GT</td>
<td>Gelatinization Temperature</td>
</tr>
<tr>
<td>HSD</td>
<td>Honest significant difference</td>
</tr>
<tr>
<td>IBPGR</td>
<td>International Board for Plant Genetic Resources</td>
</tr>
<tr>
<td>ICP-OES</td>
<td>Inductively coupled plasma optical emission spectrophotometer</td>
</tr>
<tr>
<td>IRRI</td>
<td>International Rice Research Institute</td>
</tr>
<tr>
<td>IRTP</td>
<td>International Rice Testing Programme</td>
</tr>
<tr>
<td>KER</td>
<td>Kernel Elongation Ratio</td>
</tr>
<tr>
<td>L/B</td>
<td>Length/Breadth</td>
</tr>
<tr>
<td>NaOH</td>
<td>Sodium hydroxide</td>
</tr>
<tr>
<td>µg</td>
<td>Microgram</td>
</tr>
<tr>
<td>mg</td>
<td>Milligram</td>
</tr>
<tr>
<td>mm</td>
<td>Millimeter</td>
</tr>
<tr>
<td>ppm</td>
<td>Parts per million</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

1.1 Introduction

Pigmented rice helps accelerate metabolism of the brain, prevent headache, relieve constipation, prevent colon cancer, regulate blood sugar level, prevent heart disease, lower blood pressure and prevent Alzheimer’s disease (Jiamyangyuen and Ooraikal, 2008). Additionally, antioxidant activities in pigmented rice are higher than in white rice (Lum and Chong, 2012). Brown rice or pigmented rice is defined as any kind of rice that retains its outer layer of bran and germ (Santiaguel, IRRI). According to Romero (2013), a researcher from Philippine Rice Research Institute, 15% of riboflavin, 68% of niacin, 90% of calcium, 75% of phosphorus, 67% of vitamin B3, 80% of vitamin B1, 90% of vitamin B6, half of manganese, 60% of iron and all of the dietary fibre and essential fatty acids in brown rice. Loss of all those minerals and vitamins results in manually incorporation of B1, B3 and iron into white rice. This shows that white rice do not naturally retain those vitamins and mineral anymore. On the other hand, brown rice which has its bran and germ still intact retains these nutrients and is healthier to the end user. Regular intake of brown rice is a healthier alternative to white rice.

Grain cooking quality dictates the price of rice in the market for the farmers. Good grain quality fetches higher price for the farmers (Subudhi, et al., 2012). Therefore, the cooking quality of grain became farmers’ top concern instead on insect/disease resistance of rice. Unsatisfactory cooking quality hampers the acceptance and spread of the modern cultivar. As a result of this, quality traits of the rice grain receive special emphasis beginning last decade.
Rice’s cooking and eating quality is affected by amylose. According to Juliano (1979), starch constitutes 90% of the rice grains dry weight. It consists of the linear fractioned amylose and branched fractioned amyllopectin. Amylose content in rice causes the rice to be flaky and dry or sticky and moist. Next, gelatinization temperature which is the temperature at which water is absorbed and the starch granules swell irreversibly causing loss in crystallinity. This property determines the time required to cook rice. High gelatinization temperature of rice causes the rice to become excessively soft and disintegrate due to overcooking. Rice with high gelatinization temperature is not desirable in rice market. Then, there is rice gel consistency. Rice tenderness or toughness is determined by gel consistency. It differentiates high amylose content rice into three categories which are very flaky, flaky and soft (Jennings et al., 1979). Rice with soft gel consistency is generally most preferable. This is because it is tenderer compared to hard gel consistency which makes the rice with high amylose content harder to chew.

Sabah is known to be rich in pigmented rice variety. A study done by Chaundhary (2003) used a naming method whereby the rice are named according to their bran colour form by anthocyanins in the pericarp, seed coat and aleurone. Some varieties of traditional pigmented rice in Sabah are Wehani, Bukit Merah, Bukit Laun, Purak, Rahum, Sarawak, Silia, Pilit Topurak, Emas, Lahum, Sompung, Merah, Tadong Bukit, Gompungut, Wangi, Merah, Tadong Sawah, Taragong, Baragong, Gaur, Tenghilan and Gongdokan. Among places in Sabah that produces pigmented rice are Penampang, Kota Belud and Tuaran. Exact number of pigmented variety in Sabah has not yet been established. Many past studies have establish that pigmented rice is a healthier alternative to white rice, however, there are not many in depth studies, reports or published paper on pigmented Sabah rice regarding their structure, quality traits, physicochemical qualities, nutrition, antioxidant activities, yield and agronomic traits. Also, there are not many studies done on pigmented rice globally, let alone pigmented rice in Sabah. Moreover, these pigmented rices may contain possible useful trait that could be used to improve the current rice quality such as its agronomic trait. Thus, it is important that local pigmented rice to be screened for their physicochemical characteristics to determine if there is any possible trait to be extracted and incorporated into Malaysia’s commercial rice breed.
1.2 Objectives

1. To determine morphological characteristics of traditional rice in Sabah
2. To determine the cooking quality of rice consisting of amylose content, gelatinization temperature, gel consistency and mineral content of traditional rice in Sabah.

1.3 Justification

It is important to know if there is any possible useful trait among all the tested varieties. Moreover, it is crucial to prove that there are significant statistical differences among the varieties to ascertain superior variety. Additionally, this study is done to discern if there is any potential genotype of traditional rice in Sabah that could be used in breeding programme and popularized among the farmers. Thus, it is important that the superior genotype of the traditional pigmented rice in Sabah can be identified and integrated into breeding programme in order to improve commercially produced rice quality. This study is done because there is no specific past literature or studies that had been done on this topic. There are no published references on quality traits of traditional pigmented rice in Sabah. Also, there is not yet characterization in terms of cooking quality of pigmented rice in Sabah.

1.4 Significance of Study

The data collected from this study can be used to determine the availability of potential useful trait in Sabah traditional rice for the breeding programme. This study will provide a record of the cooking quality traits of Sabah traditional rice as reference for future study regarding the varieties of traditional rice in Sabah.

1.5 Hypothesis

H₀: There is no significant difference in the amylose content, gelatinization temperature, gel consistency and mineral content among the pigmented traditional Sabah rice varieties.
H₀: There is significant difference in the amylose content, gelatinization temperature, gel consistency and mineral content among the pigmented traditional Sabah rice varieties.
CHAPTER 2

LITERATURE REVIEW

2.1 Oryza sativa


2.1.1 Distribution

A study by Oka and Morishima suggested that Asian rice, Oryza sativa, indica and japonica were domesticated from Oryza rufipogon, a wild rice species. Bayesian phyllogenetic analyses dated the origin of rice domestication begun 8,200-13,500 years ago which was consistent with Fuller et al.’s report saying that rice was cultivated primarily around that time in the Yangtze Valley of China. Now, continents
such as Europe, Africa, tropical and temperate Asia, Australia, North and South America are cultivating rice. China is the biggest rice producer in the world according to Food and Agriculture Organization (FAO) (2012).

2.1.2 Edible Plant Parts and Uses

After being harvested, rice grain will be dehulled to remove the inedible hull. Dehulling often results in white polished rice with the bran removed. On the other hand, brown rice is the whole, unpolished kernel with both its bran and germ intact, only the outer husk removed. Brown rice is recently gaining popularity as “health food” due to the nutrition it carries. Rice is often consumed as whole grains either boiled or steamed in water. Instead of whole grain, rice is processed into flour and can be used to make many delicacies such as rice noodles, rice cakes (dumplings), porridge and beverages.

2.1.3 Botany

Rice is an annual grass. It can grow up to 50 to 130 cm tall, up to 5 m long in deep-water rices forming small tufts. *Oryza* has fibrous roots, arising from the base of the shoots. Its culm erect to ascending, glabrous, composed of a series of nodes and internodes with its number depending on the cultivar and growing season. Each node is with a single leaf, and sometimes also with a tiller or adventitious roots. Usually, internodes are short at the base of the plant and gradually augment towards the top. Two ranks of leaves with its sheaths initially enclosing each other in turn forming a pseudostem which enclose the internodes later. Its ligule is triangular to linear-lanceolate in shape and is 1 cm to 1.5 cm long, often split with its auride mostly present, falcate, 1 mm to 5 mm long and hairy. Leaf blade is linear usually 24 cm to 60 cm x 0.6 cm to 2.2 cm area, glabrous with surface usually smooth to scrabrous and often has spiny hairs on margin. Inflorescence occurs at terminal panicle with 50 to 500 spikelets depending on the cultivar. Single spikelets is borne on a short pedicel. They can be oblong to lanceolate in shape measuring 7 mm to 11 mm long containing single bisexual flower with two small glumes, a large 6-10 mm long. It has boat-shaped lemma sometimes with awn up to 15 cm long and similarly, palea with very short awn, six stamens, a broad ovary, and two plumose stigmas as shown in Figure 12, 13, 14 and 15. Rice grain, also known as the fruit or caryopsis is varying in size, shape and colour.
Figure 2.1  Ripening padi in lowland padi field.
Source:  Lim, T. K., 2013

Figure 2.2  Padi plants with ripe harvestable ears.
Source:  Lim, T. K., 2013

Figure 2.3  Close-up of ripening padi.
Source:  Lim, T. K., 2013
2.2 White Rice

As defined above, white rice is rice grain with its husk, bran and germ removed and polished. Thus, according to a study by Romero (2013), polishing brown rice to white rice result in 15% of proteins, 85% of fats, 80% of thiamine, 70% of riboflavin, 68% of niacin, 90% of calcium, 75% of phosphorus and 60% other minerals loss. Despite the nutrient loss, reason for dehulling is that firstly, it cooks faster and tends to create a more tender eating sensation. Next, it is perceived that white rice tastes better that pigmented rice. Lastly, the outer layer which contains fats may go rancid if rice is poorly stored or not eaten soon enough. White rice in this sense has a longer shelf life. Brown rice should be kept in refrigerator and must be eaten within six months.

2.3 Pigmented Rice

As defined by Singapore’s Government Health Promotion Board (2013), the colour of rice is determined by the type and amount of anthocyanins (colour pigments) in the rice bran. Brown Rice generally refers to rice that is unpolished where only the hull is removed but retained the germ and bran. Because of this, unpolished rice is considered whole-grain and hence has higher nutritive value. Quoted from the same source, brown rice is said to contain five times the fibre and two times the iron of white rice. Containing a variety of anthocyanins that renders the Red Rice red or maroon colour bran, it possesses similar amount of fibre, however, Red Rice contains twice the amount of iron and six times the amount of zinc as compared to Brown Rice. On the other hand, Black Rice contains black coloured bran layer due to its unique anthocyanin combination and when cooked, these anthocyanins turn into deep purple
colour. Black Rice contains three times the amount of fibre compared to brown rice. Forbidden Rice also known as Purple Rice is a short grain variant of black rice, purple in its uncooked state and deep purple after cooked. This type of rice contains twice the iron and four times the content of zinc of brown rice.

2.4 Benefits of Pigmented Rice

According to Jiamyangyuen and Ooraikal (2008), pigmented rice helps accelerate metabolism of the brain, prevent headache, relieve constipation, prevent colon cancer, regulate blood sugar level, prevent heart disease, lower blood pressure and prevent Alzheimer’s disease. Additionally, antioxidant activities in pigmented rice are higher than in white rice (Lum and Chong, 2012). Other than the aforementioned benefits, pigmented rice contains nutritive/medicinal value, anti atherosclerotic function, cardioprotective, hepatoprotective, antianaphylactic/antiallergic activity and some traditional medicinal uses.

2.4.1 Mineral Content

Cited from United States Department of Agriculture (2012), mineral composition of long grained, raw, brown rice per 100g of edible portion had been reported to be higher than long grained, regular, raw, unenriched white rice per 100g edible portion. Iron in brown rice is 1.47 mg compared to white rice which is 0.80 mg. Additionally, brown rice is higher in Magnesium (Mg), Manganese (Mn), Copper (Cu), Zinc (Zn) and Sodium (Na) than white rice. In another study by Huang and Ng (2011), they found that in 16 commercial Taiwanese rice, brown rice is richer in vitamin E, total tocopherols, total tocotrienols and γ-oryzanol than polished rice. In general, according to a study by Sharma et al. (2012), red rice landraces contains higher mineral than improved white rice variety.

2.4.2 Antioxidant Activity in Pigmented Rice

Extracts of Sangyod (a red pigmented rice), unpolished brown rice and rice bran variety exhibited significantly higher antioxidant activity that Dawk Mali 105 (commercial white-coloured rice) that only exhibited moderate to low activity as mentioned by Srisawat et al. (2010). Rattanachiththawat et al. (2010) quoted that red
unpolished Thai rice was discovered to be rich with phenolic compounds that result in good antioxidant ability and may affect oxidative stress prevention due to their higher flavonoid and phenolic contents which were 2.5 and 3 times higher than those of Dawk Mali 105.

2.4.3 Anticancer Activity

Nam et al. (2005) stated anti-tumour-promoting activity through inhibition of Epstein-Barrvirus early-antigen activation (EBV-EA) induced by the tumour promoter 12-0-tetradecanoylphorbol-13-acetate was demonstrated by ethanol-water bran extracts of 5 pigmented rice cultivars. Additionally, two bioactive anthocyanin compounds, peonidin 3-glucoside and cyanidin 3-glucoside that were isolated from black rice showed growth inhibition of HS578T human breast cancer cells via G2/M arrest (Chen et al., 2005).

2.4.4 Anti Atherosclerotic Activity

Black and red rice are maybe effective in reducing atherosclerotic plaques on the aorta of rabbits that were fed with cholesterol-enriched diet. According to Chen et al. (2000), aorta plaque which is the percentage of total surface in the black and red rice groups of rabbit are significantly lower than that in the white rice group. Also, attenuation of atherosclerotic plaque formation was found in mice supplied with diets containing black rice pigment fraction.

2.4.5 Cardioprotective Activity

Wang et al. (2007) proved that dietary supplementation of black rice pigment fraction (BRF) exerts cardioprotective effects by improving plasma antioxidant status and inhibiting inflammatory factors. As compared to white rice fraction supplementation, plasma total antioxidant capacity was greatly enhanced and plasma levels of soluble vascular cell adhesion molecule-1 (sVCAM-1) soluble CD$^{+}$ ligand and high sensitive C-reactive protein (hs-CRP) were significantly reduced by BRF supplementation. In another study, it is reported that consumption of a mixture of brown rice and black rice significantly reduce weight, body mass index and body fat as in comparison to white rice (Kim et al., 2008).
2.4.6 Hepatoprotective Activity

Anthocyanin-rich extract from black rice exhibited hepatoprotective ability on chronically alcohol-induced liver damage in rats (Hou et al., 2010). Administration black rice extract along with alcohol significantly decreased activities of aspartate transaminase, alanine transaminase, gamma glutanyl transferase in serum, hepatic malondialdehyde levels, concentration of serum and hepatic triglyceride and total cholesterol in liver damaged rats. Rat treated with black rice extract also showed better profile of antioxidant system with normal glutathione peroxidase, superoxide dismutase and glutathione S-transferase activities.

2.4.7 Antianaphylactic/Antiallergic Activity

Choi et al. (2007) declared that etanol-water (70% v/v) extracts from five pigmented black rice brans were discovered to be more effective than an extract from a non-pigmented rice cultivar in suppressing the release of histamine and β-hexosaminidase from basophilic RBL-2H3 cells stimulated with both Ionophore A23187 and immunoglobulin E (IgE)-antigen complexes.

2.4.8 Traditional Medicinal Uses

Brown rice extracts is used to treat breast and stomach cance, and warts. On top of that, it has also been used to treat indigestion. In addition, polishing from rice mill is sometimes used to treat beri-beri.

2.5 Grain Eating and Cooking Quality

Juliano (2013) pointed out that eating and cooking quality of rice depends on starch properties. Apparent amylose content is governed by linear starch while gelatinization temperature and gel consistency by branched starch properties. Grain quality in rice is very difficult to define with precision as preferences for quality vary from country to country. Few people realize its complexity and various quality components involved. The concept of quality varies according to the preparations for which grains are to be used. Although some of the quality characteristics desired by grower, miller and
REFERENCES


Ubong, I. and Ibrahim, N. (n.d.). *Developing local-level indicators to measure the sustainability of rice production areas in Sabah*. Retrieved December 8, 2013,


