EXPLORING OF MALAYSIAN UNDERUTILISED ‘SUPER’ FRUITS FOR HUMAN NUTRITION AND SUSTAINABLE DIETS

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Outline of Presentation

• Introduction to underutilized fruits
• Nutritional composition of Dabai & Bambangan
• Health promoting properties
• Concluding remarks
• Fruits - “food of the god”
• Inverse correlation between the incidence of chronic diseases and fruits consumption
• Insufficient consumption of fruits & vegetables is one of the ten leading global disease risk factors – WHO (2002)
• Many studies have been focused on commercial & export fruits
Several studies have reported that dietary fiber and antioxidants are two dietary factors involved cardiovascular disease (Arts and Hollman, 2005; He et al., 2007; Pérez-Jiménez et al., 2008; Larsson et al., 2009).

Fruits and vegetables have received much attention as a source of biologically active substances because of their antioxidant and dietary fiber properties (Dillard and German, 2000; Larsson et al., 2009).
NUTRITION AND BIODIVERSITY

AGRICULTURAL BIODIVERSITY

UNDERUTILIZED PLANT SPECIES: FRUITS & VEGETABLES

Terms: indigenous, rare, exotic, wild, under-exploited

➢ Role of biodiversity: source of foods, income for rural people for sustaining and strengthening food, nutrition, health and livelihood security

➢ Contribute to → realization of MDGs, to halve the proportion of people who suffer from hunger and ensure environmental sustainability (FAO, 2010).

Species with underexploited potential to contribute in food security, health and nutrition, income generation and environmental services (GFU, 2007)
In Malaysia - > 370 species of fruits

- Commercial fruits – papaya, mango, star fruits, pineapple, guava
- Rare fruits
- Indigenous fruits
- Wild fruits
- Exotic fruits
Underutilized Fruits (rare, indigenous, wild, exotic; long history of consumption & used by the locals)
Cherry (Malpighia punicafolia)

‘Kerandang’ (Carissa congesta)

‘Rokam manis’ (Flacourtia rukam)

‘Kuini’ (Mangifera odorata)

‘Asam gelugor’

‘Bidara’ (Ziziphus mauritania)

‘Jambu bol’ (Syzygium malaccense)

‘Kuning telur’ (Pouteria campechiana)

‘Jambu susu’ (Syzygium jambos)
Underutilised fruits of Sarawak
Sarawak State Department of Agriculture has identified 6 underutilized fruits → Economic Fruit Crop
Antioxidant capacity and total phenolic content of Malaysian underutilized fruits

Emmy Hainida Khairul Ikram, Khoo Hock Eng, Abbe Amin Ismail, Salma Idris, Azrina Azlan, Halimatul Norzatol Akmar Mat Diton, Ruzaidi Azli Mohd Mohd Haji

Characterisation of fibre-rich powder and antioxidant capacity of Mangifera pажang K. fruit peels

Fouad Abdulrahman Hassan, Amin Ismail, Azizah Abdul Hamid, Azrina Azlan, Sadeq Hasan Al-sheeragi

Response surface optimisation for the extraction of phenolic compounds and antioxidant capacities of underutilised Mangifera pажang Kosterm. peels

K. Nagendra Prasad, Fouad Abdulrahman Hassan, Bao Yang, Kin Weng Kong, Ramakrishnan Nagasundara Ramanan, Azrina Azlan, Amin Ismail
Bambanganan and Dabai

- Sarawak; rich in biodiversity
- 75 species of indigenous tree from 18 families with NOBLE quality fruits (Lau, 2009)
Canarium odontophyllum Miq.

Family: Burseraceae

Local name: Dabai/Sibu olive
Dabai fruits

- rarely eaten, unfamiliar and unknown elsewhere apart from Sarawak
- seasonal in nature and appreciated as an exotic fruit
- whole ripe fruit is soaked in warm water for 3-5 minutes to soften the pulp and eaten
- sometimes it is consumed seasoned with sugar, salt, pepper or sauce
- the stony hard seed is discarded
Dabai fruits
Dabai fruits - physical properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Mean (± Standard deviation, SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bigger size</td>
</tr>
<tr>
<td>Length (cm)</td>
<td>4.10 (± 0.11)</td>
</tr>
<tr>
<td>Width (cm)</td>
<td>2.79 (± 0.13)</td>
</tr>
<tr>
<td>Mass (g)</td>
<td>18.28 (± 1.59)</td>
</tr>
<tr>
<td>Mass (g) of fraction:</td>
<td></td>
</tr>
<tr>
<td>Skin</td>
<td>1.02 (± 0.19)</td>
</tr>
<tr>
<td>Flesh</td>
<td>11.22 (± 0.93)</td>
</tr>
<tr>
<td>Kernel</td>
<td>6.79 (± 0.81)</td>
</tr>
<tr>
<td>Thickness (cm)</td>
<td>0.5 (± 0.0)</td>
</tr>
<tr>
<td>Sphericity index, $S_c$ (%)</td>
<td>43.62 (± 0.76)</td>
</tr>
<tr>
<td>Aspect ratio, $R_a$ (%)</td>
<td>67.37 (± 4.32)</td>
</tr>
</tbody>
</table>

*ND = not determined
Dabai fruits
• Distribution

Locations of Dabai (*Canarium odontophyllum*) production.


Bambangan: Grown wild in Borneo Island includes Sabah, Sarawak, Brunei and East Kalimantan
### Proximate Composition of Fresh Pulp (%)

<table>
<thead>
<tr>
<th></th>
<th><em>Canarium Odontophyllum</em> (Dabai) (Voon &amp; Kueh, 1999)</th>
<th><em>Olea europea</em> (Olive) (McCance &amp; Widdowson, 2000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>~235 kcal/100g</td>
<td>16.35-68.08</td>
</tr>
<tr>
<td>Fat</td>
<td>41.3</td>
<td>16.36-27.97</td>
</tr>
<tr>
<td>Protein</td>
<td>26.2</td>
<td>0.72-2.16</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>3.8</td>
<td>8.02-12.28</td>
</tr>
<tr>
<td>Ash</td>
<td>22.1</td>
<td>0.35-1.24</td>
</tr>
</tbody>
</table>

#### Mineral content (g/100g)

<table>
<thead>
<tr>
<th>Element</th>
<th><em>Canarium Odontophyllum</em> (Dabai) (Voon &amp; Kueh, 1999)</th>
<th><em>Olea europea</em> (Olive) (McCance &amp; Widdowson, 2000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium</td>
<td>0.81</td>
<td>0.53-3.39</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.10</td>
<td>0.01-0.06</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.20</td>
<td>0.02-0.16</td>
</tr>
<tr>
<td>Sodium</td>
<td>-</td>
<td>0.01-0.22</td>
</tr>
<tr>
<td>Iron</td>
<td>0.0013</td>
<td>0.0003-0.009</td>
</tr>
<tr>
<td>Copper</td>
<td>0.0007</td>
<td>0.0000003-0.0005</td>
</tr>
<tr>
<td>Zink</td>
<td>0.00047</td>
<td>0.0001-0.003</td>
</tr>
<tr>
<td>Selenium</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

#### Fatty acid composition of pulp oil (%)

<table>
<thead>
<tr>
<th>Fatty acids</th>
<th><em>Canarium Odontophyllum</em> (Dabai) (Voon &amp; Kueh, 1999)</th>
<th><em>Olea europea</em> (Olive) (McCance &amp; Widdowson, 2000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFA</td>
<td>43.42 ± 0.05</td>
<td>22.00-11.70</td>
</tr>
<tr>
<td>MUFA</td>
<td>42.53 ± 0.06</td>
<td>78.00-41.65</td>
</tr>
<tr>
<td>PUFA</td>
<td>14.05 ± 0.09</td>
<td>60.10-6.23</td>
</tr>
<tr>
<td>Oleic acids</td>
<td>14.05 ± 1.96</td>
<td>57.85-72.70</td>
</tr>
</tbody>
</table>
# Fatty acids of Dabai Kernel

## Fatty acid composition of kernel oil (Azrina et al., 2010)

<table>
<thead>
<tr>
<th></th>
<th>Dabai</th>
<th>Cocoa Butter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Saturated fatty acid</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C16:0</td>
<td>46.3</td>
<td>8.4</td>
</tr>
<tr>
<td>C18:0</td>
<td>4.8</td>
<td>35.4</td>
</tr>
<tr>
<td><strong>Monounsaturated fatty acid</strong></td>
<td>35.6</td>
<td>35.5</td>
</tr>
<tr>
<td>C16:1</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>C18:1</td>
<td>35.1</td>
<td>15.3</td>
</tr>
<tr>
<td><strong>Polyunsaturated fatty acid</strong></td>
<td>3.7</td>
<td>3.1</td>
</tr>
<tr>
<td>C18:2</td>
<td>0.7</td>
<td>0</td>
</tr>
</tbody>
</table>
## Total Phenolic Content of Dabai oil

<table>
<thead>
<tr>
<th>Type of oil</th>
<th>Total phenolic content (mg GAE/100 g oil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dabai kernel oil</td>
<td>3.94</td>
</tr>
<tr>
<td>Palm oil</td>
<td>4.70</td>
</tr>
<tr>
<td>Dabai pulp oil (without skin)</td>
<td>14.0</td>
</tr>
<tr>
<td>Dabai pulp oil (with skin)</td>
<td>20.2</td>
</tr>
<tr>
<td>Olive oils</td>
<td>10.85 – 44.43</td>
</tr>
</tbody>
</table>
## Carotenoid composition

<table>
<thead>
<tr>
<th>Carotenoids (µg/g fresh weight)</th>
<th>Peel</th>
<th>Pulp</th>
<th>Seed</th>
</tr>
</thead>
<tbody>
<tr>
<td>all-trans-lutein</td>
<td>1.62 ± 0.03</td>
<td>0.36 ± 0.01</td>
<td>0.67 ± 0.01</td>
</tr>
<tr>
<td>9-cis-lutein</td>
<td>0.32 ± 0.01</td>
<td>0.10 ± 0.02</td>
<td>0.13 ± 0.04</td>
</tr>
<tr>
<td>13-cis-lutein</td>
<td>0.62 ± 0.01</td>
<td>0.16 ± 0.009</td>
<td>0.11 ± 0.01</td>
</tr>
<tr>
<td>di-cis-β-carotene</td>
<td>0.69 ± 0.01</td>
<td>0.35 ± 0.0005</td>
<td>0.37 ± 0.01</td>
</tr>
<tr>
<td>15- cis - β-carotene</td>
<td>18.29 ± 2.4</td>
<td>11.9 ± 0.3</td>
<td>8.38 ± 0.4</td>
</tr>
<tr>
<td>9-cis-β-carotene</td>
<td>39.61 ± 0.28</td>
<td>5.8 ± 0.69</td>
<td>3.20 ± 0.3</td>
</tr>
<tr>
<td>all-trans-β-carotene</td>
<td>69.52 ± 1.0</td>
<td>31.1 ± 0.76</td>
<td>15.1 ± 3.0</td>
</tr>
<tr>
<td>13-cis-β-carotene</td>
<td>19.43 ± 1.2</td>
<td>5.7 ± 0.5</td>
<td>5.6 ± 0.27</td>
</tr>
<tr>
<td>Total</td>
<td>149.48</td>
<td>55.47</td>
<td>33.56</td>
</tr>
</tbody>
</table>
Potential Health Benefits

Explore cardioprotective effect of Dabai parts using New Zealand White rabbits

Hypercholesterolemic (0.5% Cholesterol) (8 weeks) Treatment

Normal cholesterol (4 weeks) Prevention
HYPERCHOLESTEROLEMIC CONDITION

NC: negative control, PC: positive control
HS: simvastatin
HP: pulp oil
HK: kernel oil
HF: fullfat pulp
HD: defatted pulp

Each value represents the mean ± SD.
Percentage of lesion area of intimal surface of aorta of animal groups

- PC: 2.56%
- HD: 4.54%
In hypercholesterolemic condition,

• Plasma lipids and antioxidant status were improved to an extent BETTER than STATIN following intake of defatted pulp

• Fat extracted from pulp of dabai has more important effect compared to kernel
Conclusions

• Dabai has high health-promoting components ....’super’ fruit
• Dabai fractions offer prevention against CVD
• Attributed to bioactivity of multiple components in Dabai (vitamins, minerals, fiber, phytonutrients especially phenolic compounds)
Mangifera pajang (bambangan)

- Underutilised fruit
- Grown wild in Borneo Island includes Sarawak + Brunei
- 2-3 fold bigger than commercial mango
- Thick peel and
- Pleasant taste and aroma
- Its flesh has rich in antioxidants
### Nutrient Composition of Bambangan

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Pulp</th>
<th>Juice Powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>86.84</td>
<td>10.01</td>
</tr>
<tr>
<td>Protein</td>
<td>1.13</td>
<td>3.78</td>
</tr>
<tr>
<td>Fat</td>
<td>1.98</td>
<td>1.75</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>21.02</td>
<td>76.09</td>
</tr>
<tr>
<td>Soluble Dietary Fiber</td>
<td>0.43</td>
<td>3.30</td>
</tr>
<tr>
<td>Insoluble Dietary Fiber</td>
<td>5.26</td>
<td>0.80</td>
</tr>
<tr>
<td>Total Dietary Fiber</td>
<td>4.84</td>
<td>0.12</td>
</tr>
<tr>
<td>Ash</td>
<td>0.42</td>
<td>0.68</td>
</tr>
<tr>
<td>Gross Energy</td>
<td>428.68</td>
<td>335.23</td>
</tr>
</tbody>
</table>
### Nutrient Composition of Bambangan

#### Antioxidant Properties of Bambangan Pulp and Juice Powder

<table>
<thead>
<tr>
<th>Antioxidant Parameter</th>
<th>Pulp</th>
<th>Juice Powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascorbic Acid (mg/100 g)</td>
<td>46.31</td>
<td>132.14</td>
</tr>
<tr>
<td>β-Carotene (mg/100 g)</td>
<td>42.21</td>
<td>35.59</td>
</tr>
<tr>
<td>Total Phenolic Content (mg GAE/100 g)</td>
<td>26.09</td>
<td>19.30</td>
</tr>
<tr>
<td>Ferric Reducing Antioxidant Capacity (mM/100 g)</td>
<td>26.50</td>
<td>39.58</td>
</tr>
<tr>
<td>DPPH Radical Scavenging Activity (% in 1.0 mg/mL)</td>
<td>43.25</td>
<td>52.61</td>
</tr>
</tbody>
</table>
Identification and Quantification of Phenolic Compounds in Bambangan (Mangifera pajang Kort.) Peels and Their Free Radical Scavenging Activity

Fouad Abdulrahman Hassan, Amin Ismail, Azizah Abdul Hamid, and Azrina Azlan

Department of Nutrition and Dietetics, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, UPM Sandang 43400, Serdang, Malaysia.

Department of Food Science, Faculty of Agriculture, Universiti Putra Malaysia, Malaysia.

Table 3
Monosaccharide composition of SDF and IDF of the FRP.

<table>
<thead>
<tr>
<th>Monosaccharide</th>
<th>Fibre-rich powder (% dry weight)</th>
<th>Soluble dietary fibre</th>
<th>Insoluble dietary fibre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n.d.</td>
<td>1.15 ± 0.15</td>
<td></td>
</tr>
<tr>
<td>Glucose</td>
<td>2.49 ± 0.23</td>
<td>1.17 ± 0.01</td>
<td></td>
</tr>
<tr>
<td>Rhamnose</td>
<td>0.44 ± 0.02</td>
<td>0.20 ± 0.02</td>
<td></td>
</tr>
<tr>
<td>Arabinose</td>
<td>4.89 ± 0.28</td>
<td>3.05 ± 0.13</td>
<td></td>
</tr>
<tr>
<td>Mannose</td>
<td>12.49 ± 0.55</td>
<td>4.87 ± 0.22</td>
<td></td>
</tr>
<tr>
<td>Xylose</td>
<td>0.40 ± 0.14</td>
<td>0.09 ± 0.01</td>
<td></td>
</tr>
<tr>
<td>Fructose</td>
<td>0.15 ± 0.01</td>
<td>0.10 ± 0.01</td>
<td></td>
</tr>
<tr>
<td>Neutral sugars</td>
<td>21.68 ± 0.32</td>
<td>6.03 ± 0.53</td>
<td></td>
</tr>
<tr>
<td>Uronic acids</td>
<td>11.75 ± 0.23</td>
<td>7.60 ± 0.11</td>
<td></td>
</tr>
<tr>
<td>Klason lignin</td>
<td>n.d.</td>
<td>21.51 ± 0.47</td>
<td></td>
</tr>
<tr>
<td>Total NSP</td>
<td>33.41 ± 0.32</td>
<td>17.26 ± 0.52</td>
<td></td>
</tr>
</tbody>
</table>

n.d. Represents not detected. Mean values ± STD (n = 3). NSP is the non-starch polysaccharide representing the following equation: NSP = neutral sugars + uronic acid.

Figure 2. HPLC profile of phenolic compounds in Mangifera pajang peel, peak identification: 0, unknown; 1, gallic acid; 2, protocatechuic acid; 3, catechin; 4, chlorogenic acid; 5, methyl gallate; 6, mangiferin; 7, 4-hydroxybenzoic acid; 8, vanillic acid; 9, ethyl gallate; 10, p-coumaric acid; 11, ferulic acid; 12, rutin; 13, ellagic acid; 14, morin; 15, daidzein; 16, kaempferol.
Explore health benefits of different dosage of Bambangan juice using New Zealand White rabbits

**Control:** Rabbits fed with 1% cholesterol without any treatment for 70 days

**Group 1:** 1% cholesterol + 5% Bambangan juice powder (BJP)/kg/day

**Group 2:** 1% cholesterol + 15% BJP/kg/day

**Group 3:** 1% cholesterol + 25% BJP/kg/day

**Group 4:** 1% cholesterol + 35% BJP/kg/day

Hypercholesterolemic (1.0% Cholesterol) (10 weeks)
The graph shows the changes in HDL-C and LDL-C levels over 70 days across different treatment groups and dietary conditions.

### HDL-C (mmol/L)
- **Day 0**
  - Normal Diet: [Value]
  - Control: [Value]
  - Group 1: [Value]
  - Group 2: [Value]
  - Group 3: [Value]
  - Group 4: [Value]

- **Day 70**
  - Normal Diet: [Value]
  - Control: [Value]
  - Group 1: [Value]
  - Group 2: [Value]
  - Group 3: [Value]
  - Group 4: [Value]

### LDL-C (mmol/L)
- **Day 0**
  - Normal Diet: [Value]
  - Control: [Value]
  - Group 1: [Value]
  - Group 2: [Value]
  - Group 3: [Value]
  - Group 4: [Value]

- **Day 70**
  - Normal Diet: [Value]
  - Control: [Value]
  - Group 1: [Value]
  - Group 2: [Value]
  - Group 3: [Value]
  - Group 4: [Value]

Significance levels are indicated by letters next to the bars:
- **a** indicates a significant difference from Day 0 or Control.
- **b** indicates a significant difference among different groups.

### Treatment Groups
- Normal Diet
- Control
- Group 1
- Group 2
- Group 3
- Group 4

### Biological Context
The graph illustrates the effects of different dietary interventions on lipid profiles, specifically HDL-C and LDL-C, over a 70-day period. The significance letters (a, b) help identify which groups or conditions show statistically significant changes.
Control: Rabbits fed with 1% cholesterol without any treatment for 70 days; Group 1: 1% cholesterol + 5% Bambangan juice power (BJP)/kg/day; Group 2: 1% cholesterol + 15% JP/kg/day; Group 3: 1% cholesterol + 25% JP/kg/day; Group 4: 1% cholesterol + 35% JP/kg/day
50 g MPJP
66 mg vit. C
18 mg β-carotene
To examine the effects of Bambangan juice powder (BJP) drink on:

Lipid profiles, MDA and antioxidant levels of healthy subjects (normal cholesterol level $\leq 5.20$ mmol/l) in a 30-day cross-over, single-blind, placebo-controlled study

Experimental Design

38 subjects

→ 32 subjects

16 treated

→ 16 controlled

Week 0

1st phase

Wash-out period

2nd phase

Week 4

Week 5

Week 6

Week 9

32 treated

32 controlled
Ascorbic acid and β–carotene contents in plasma of the subjects supplemented with BJP

μmol/L

Ascorbic acid

β-carotene

Placebo

Juice powder

22%

37%
Effect of BJP on plasma total cholesterol and lipoprotein levels

- TC: 4.0 mmol/L (Placebo 18% decrease, Juice powder 13% decrease)
- HDL-C: 1.5 mmol/L
- LDL-C: 2.5 mmol/L
Effect of BJP on TG and MDA levels

- TG: Placebo vs Juice powder
- MDA: Placebo vs Juice powder

Graph shows:
- TG: 2% decrease
- MDA: 23% decrease
Effect of BJP on plasma antioxidant status

Note  
SOD: Superoxide dimutase (U/mL)  
TAS: Total antioxidant status (mmol/L)
Conclusions

• Bambangan fruit is rich in antioxidant compounds (polyphenols, vitamin C and β-carotene).

• Its antioxidant properties shown significant effects on hypolipidemic and anti-atherosclerotic, especially BJP in animal and human studies.

• BJP supplemented group (normalcholesterolemic) had shown an increase in plasma TAS, β-carotene and ascorbic acid.
Concluding remarks

- RDI on health-promoting components will help the food industry to create new products for wellbeing based on the scientific data of the tropical fruits.
- The safety and efficacy of such products on human subjects through randomized clinical trials are the ultimate before making health claims.
- Our underutilised ‘super’ fruits (UF) have a potential to be placed along with commercial & export fruits for dietary diversity, food security, poverty alleviation for rural communities.
- More research should be focused on UF
- We are really need a balanced diet includes a variety of functional food component-rich food is important for the promotion of our health.
Acknowledgements

• MOSTI, MOHE, MOA, UPM; ARC, Sarawak; MARDI, MCB
• My collaborators
  – AP Dr. Azrina Azlan, AP Dr. Muhajir Hamid, AP Dr. Chong Pei Pei, AP Dr. Azizah Abd. Hamid, UPM
  – Mr Lau Cheng Yuon, ARC; Dr. Salma, MARDI
• My international collaborators
  – Prof. F. Shahidi, Memorial Univ. of Newfoundland, Canada
  – Prof. Chin Kun Wang, Chung Shan Medical Univ., Taiwan
  – AP Dr. Sun Jian, Guangxi Agricultural Research Academy, China
  – AP Dr. Bao Yang, South China Botanical Garden, Chinese Academy of Sciences, China
  – Dr. J. Arcot, UNSW, Australia
  – Dr. Yoshito Ando, Kyushu Institute of Technology, Japan
• My students
Thank you for your attention