Developing the Market Potential of Mangosteen as A Superfruit: Focus on Quality Enhancements, Promotional Requirements and Market Expansion

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Mangosteen (Garcinia mangostana)

- Mangosteen is a tropical fruit native to Indonesia and other Southeast Asian countries which has been hailed as the “queen of tropical fruits” due to its beautiful appearance and delicious taste.

- The mangosteen recently became very popular because of the content of xanthones in the pericarp.
Mangosteen (*Garcinia mangostana*)

- The genus *Garcinia* belongs to the family *Clusiaceae* (syn. *Guttiferae*) which contains about 35 genera and up to 800 species.
- Mangosteen is maybe interspecific hybrid between
  - *G. malaccensis* and *G. celebica*
Mangosteen Fruit

**PERICARP (RIND)**
contains powerful xanthones

**MANGOSTEEN FRUIT**
delicious healthy fruit
# Mangosteen Fruit Properties

<table>
<thead>
<tr>
<th>No</th>
<th>Properties</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Edible Portion</td>
<td>29 %</td>
</tr>
<tr>
<td>2</td>
<td>Energy</td>
<td>63 kcal</td>
</tr>
<tr>
<td>3</td>
<td>Protein</td>
<td>0,6 g</td>
</tr>
<tr>
<td>4</td>
<td>Fat</td>
<td>0,6 g</td>
</tr>
<tr>
<td>5</td>
<td>Carbohydrate</td>
<td>15,6 g</td>
</tr>
<tr>
<td>6</td>
<td>Ca</td>
<td>8 mg</td>
</tr>
<tr>
<td>7</td>
<td>P</td>
<td>12 mg</td>
</tr>
<tr>
<td>8</td>
<td>Fe</td>
<td>1 mg</td>
</tr>
<tr>
<td>9</td>
<td>Vitamin B1</td>
<td>0,03 mg</td>
</tr>
<tr>
<td>10</td>
<td>Vitamin C</td>
<td>2 mg</td>
</tr>
</tbody>
</table>
Xanthone is Phytonutrient

- Plant-derived compounds (phyto-)
- that promote health (nutrition)

**Secondary metabolites:**
- Plants synthesize compounds that do not appear to be directly related to their growth and development.
- Many of these compounds hold promise for human health ➔ phytonutrients.
Xanthones

- Biologically active plant phenols
- Have a 6 carbon ring structure with double frame carbon.
- $\text{C}_{13}\text{H}_8\text{O}_2$
- All xanthones have the same frame structure, specificity is marked on the side chain of 1 to 8 carbon
- This structure makes xanthones very stable and versatile.
Xanthones profile in Indonesian mangosteen hull extract

(Kurniawati, Poerwanto, Sobir, Effendi, and Cahyana)

- 6 compounds were identified based on the UV spectrum and m/z:
  - α- mangostin,
  - β-mangostin
  - isomangostin,
  - gartanin,
  - 8-deoxygartanin and
  - 9-hydroxycalababanxanthone,

- 6 compounds were identified based on the m/z:
  - mangostanol
  - mangoxanthicone
  - mangostinone
  - mangostenone A
  - mangostenone B
  - 6-O-methylmangostanine
Xanthones Structures from Indonesian Mangosteen
(Kurniawati)

(1) 3-isomangostin
(2) 8-desoxygartanin
(3) gartanin
(4) 8-mangostin
(5) 9-hydroxycalabaxanthone
(6) 8-mangostin

(1) Peak 2=\((\text{Dehydration 6-O-})
R^2=\text{R}^3=\text{Me}, R^4=\text{C}\)
(2) Peak 7,8,9 = Mangostanol methylmangostanone; \(R^4=\text{A}\)
(3) Peak 11= Mangoxanthone
\(R^1=\text{OH}, R^2=\text{H}\)
(4) Peak 13= Mangostininone
\(R=\text{H}\)
(5) Peak 19= Mangostenone A
(6) Peak 20= Garciniauran 380.127
Factors Affecting Phytonutrient in Fruits and Their Activity

- Genotypes
- Growth Stage & Maturity
- Pre-harvest Conditions
  - Agro-ecology
  - Cultural Practices
    - Fertilizer,
    - Compost,
    - Bed Structure,
    - Ground Cover,
    - Soil,
    - Elevated carbon dioxide,
    - Pre-harvest application of natural compounds

- Postharvest Handling
  - Storage,
  - Modified atmosphere packaging,
  - Carbon dioxide,
  - Low oxygen treatment,
  - Heat treatment,
  - Irradiation,
  - Treatment natural compounds,
  - Fresh-cut
Our Research

- Study on the effects of genotype, agro-ecology & cultural practices on **xanthone** production in **mangosteen**:
  - 3 varieties: Wanayasa, Kaligesing, Watulimo
  - 4 location: Bogor, Purwakarta, Tasik Malaya, Trenggalek
  - Fruit growth stadium: 4, 8, 12, 16 weeks after anthesis
  - Fertilizer: N, P, K
  - Storage: at harvest, 2, & 4 weeks after harvest
Research in Xanthone

Year I (2007)
Existing mangosteen orchard
- Study on xanthone content and profile at different agro-ecology
- Study on xanthone content and profile of 3 varieties
- Xanthone accumulation after harvest
- Xanthone accumulation at several fruit growth stadiums

Year II (2008)
- Study on the role of P & K on Xanthone production
- Identification of Xanthone type related to on farm treatments of Year 1 Studies
- Study on biological activities of Xanthone related to on farm treatments
- Xanthone identification using LC-MS
- Antioxidant activity of Xanthone
- Effect of P & K on Xanthone content
- Effect of light on Xanthone production
- Effect of mangosteen peel on xanthone content
- Correlation between fruit load with xanthone content
- Distribution of xanthone in fruit peel

Year III (2009)
- Optimization of Xanthone production
- Effect of light on Xanthone production
- Effect of mangosteen peel on xanthone content
- Correlation between fruit load with xanthone content
- Distribution of xanthone in fruit peel

Research in Xanthone
1. Agro-ecology of the production center significantly affect xanthone production.

2. Xanthone accumulation in the fruit peel started at 1 month after anthesis (1.97 g/100 g crude extract), and it was highest at 4 month after anthesis (4.78 g/100 g CE).

3. Xanthone content at 0, 2, and 4 weeks after harvest was not significantly different.

4. P fertilizer (0-600 kg/tree) decreasing xanthone content in the peel.

5. Nitrogen (0-1200 g/tree) and Potassium (0-1600 kg/tree) fertilizer was not affect xanthone content in the peel.
# Xanthone Bioactive content in 5 Mangosteen Production Center in Java Island

<table>
<thead>
<tr>
<th>Production Center</th>
<th>Benzophenon</th>
<th>Xanthone Derivate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Xanthone standart</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( mg/g CE)</td>
</tr>
<tr>
<td>Wanayasa</td>
<td>8.42b</td>
<td>10.76c</td>
</tr>
<tr>
<td>Watulimo</td>
<td>20.60a</td>
<td>22.67a</td>
</tr>
<tr>
<td>Kaligesing</td>
<td>7.13b</td>
<td>11.31bc</td>
</tr>
<tr>
<td>Puspahiang</td>
<td>10.40b</td>
<td>17.46ab</td>
</tr>
<tr>
<td>Leuwiliang</td>
<td>9.46b</td>
<td>15.40bc</td>
</tr>
<tr>
<td>F test</td>
<td>**</td>
<td>*</td>
</tr>
</tbody>
</table>
# Xanthones Derivates in Mangosteen Fruit

(Kurniawati, Poerwanto, Sobir, Effendi, and Cahyana)

<table>
<thead>
<tr>
<th>Fruits Age</th>
<th>Benzop henon</th>
<th>Xanthones Derivates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month After Anthesis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8.48</td>
<td>14.67</td>
</tr>
<tr>
<td>2</td>
<td>7.94</td>
<td>16.21</td>
</tr>
<tr>
<td>3</td>
<td>8.31</td>
<td>15.74</td>
</tr>
<tr>
<td>4</td>
<td>10.80</td>
<td>15.68</td>
</tr>
</tbody>
</table>

( mg/g CE)
Effects of P Fertilizer on Mangosteen Xanthones

![Bar chart showing the effects of P fertilizer on xanthones in mangosteen.](chart.png)
Effects of N Fertilizer on Mangosteen Xanthones

![Bar graph showing the effects of N fertilizer on mangosteen xanthones. The graph compares the levels of xanthone, benzophenon, α-mangostin, and xanthone derivates at 0, 600, and 1200 mg/g CE.]
Effects of K Fertilizer on Mangosteen Xanthones

Xanthone Derivates

- Benzophenon
- Xanthone
- α-mangostin

Content (mg/g CE)

0 50 100 150 200 250 300

0 800 1600
Mechanisms of Action


1. **Antioxidant activity**
2. **Anti-angiogenesis**
3. **Anti-cancer properties**
4. **Control cell growth**
5. **Cell-to-cell communication**
6. **Anti-bacterial**

This protection can be attributed to **phytonutrient** in fruits.
## Anti-oxidant Potential of Mangosteen Hull Crude Extract

<table>
<thead>
<tr>
<th>Fruit Age (MAA)</th>
<th>IC$_{50}$ Metode</th>
<th>Ferric thiocyanate (ppm)</th>
<th>DPPH (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>74.93</td>
<td>6.31</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>75.36</td>
<td>6.79</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>77.08</td>
<td>9.57</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>71.70</td>
<td>12.81</td>
</tr>
<tr>
<td>( \alpha )-tocoferol</td>
<td></td>
<td>34.93</td>
<td>10.34</td>
</tr>
</tbody>
</table>

\( \alpha \)-tocoferol
TAC (Total Antioxidant Capacity) based on ORAC (Oxygen Radical Absorbance Capacity) test

- Magozai®: 102 570 TE/l
- Xango®: 34 000 TE/l
- Tahitian Noni Juice®: 18 000 TE/l
- Himalayan Goji Juice®: 19 000 TE/l
Properties of mangosteen peel
(claim by drug/jamu companies)

- Anti Bacteria
- Lowering Blood Sugar Levels
- Lowering Total Blood Cholesterol
- Preventing Heart Disease
- Preventing Aging
- Overcoming Tumor and Cancer
- Overcoming Gout
- Overcome Thyroid Disorders
- Hemorrhoid remedy
- Essential for fatigue
Properties of mangosteen peel
(claim by drug/jamu companies)

- Nourish the body cells from cancer initiation and tumor growth
- Eliminate pain in the body and joints
- Beautify and soften skin, smooth ageless skin free of acne
- Facilitate smooth bowel movements
- Good for women menopause
- Good for people with diabetes
- Treating high blood pressure, heart, uric acid and rheumatism
- Etc, etc, etc
Mangosteen peel extract Consumption Could Reduce The Incidence of Various Malignancy
(claim by drug/jamu companies)

- Leukemia
- Breast Cancer
- Kidney Failure
- Colon Cancer
- Brain Cancer
- Liver Cancer
- Diabetes Mellitus
- Gangrene
- Glaucoma
- Cholesterol
- Triglycerides
- Stroke
- Uric Acid
- Inflammation
- Sinusitis
- Pneumonia
- Migraine
- Osteoporosis
- Insomnia
- Prostate
- Lupus
- Typhoid
- Diarrhea
- Asthma
- Lymph Nodes
- Mumps Disease
- Hemorrhoids And Ambien
- Liver and Gallbladder
- Muscle Coordination
- Appendix Complication
- Dysmenorrhea
- Whitish
- Scarlet Fever
Results of scientific research on mangosteen

- **Antioxidant** (Herry, 2006; Kurniawati, 2011; Moongkarndi et al., 2004; Steinmetz & Potter, 1996; Sun et al., 2004; Yang et al., 2009)
- **Anti cancer** (Shan et al., 2011; Sun et al., 2004; Moongkarndi et al., 2004)
- **Anti inflammation** (Moongkarndi et al., 2004; Steinmetz & Potter, 1996; Yang et al., 2009)
- **Anti-allergy** (Steinmetz & Potter, 1996; Yang et al., 2009)
- **Anti bacteria** (Suksamrarn et al., 2003; Steinmetz & Potter, 1996; Yang et al., 2009)
- **Anti-fungal** (Steinmetz & Potter, 1996; Yang et al., 2009)
- **Anti-viral activities** (Steinmetz & Potter, 1996; Yang et al., 2009)
People responses

- Xanthone has been claimed to have a very high potential for human health.
- These products are popular due to their perceived role in promoting health.
- There have been many companies that manufacture drugs and herbal extracts from mangosteen peel.
- There needs to be a scientific study on the efficacy of xanthones.
Health products origin from mangosteen
Trade and Distribution

- Multi Level Marketing:
  - Xango
  - Magozai
  - Xamthon, etc.

- TV advertisement:
  - Garcia

- Distribution through pharmacies and drug stores
In Shan et. all. (2011) report

• Mangosteen products are now one of the top-selling botanical dietary supplements [Marcason, 2006].

• In 2005:
  – these products ranked sixth in single-herb dietary supplement sales,
  – netting more than $120 million,
  – a substantial increase compared to the previous year [Garrity et al., 2004; Foote, 2007].
Results of Veronica Leigh Johnson Survey in USA 2011

• Consumers are more concerned with their health
• 66% of respondents saying they are willing to pay more for “super fruits”
• 51% believe that “super fruits” have superior health benefits than other fruits
• The target market for “super fruits” was females, with the age range being anywhere from 18-44 years old, who are moderately to highly educated
• Consumer valuing the healthy factors and the taste of the fruit itself over price or growing location.
• As long as it tastes good and is good for health, they’re buying.
Conclusion

• Based on our research that:
  – Location, variety, fertilization, fruit age, fruit characters, and storage influenced xanthone contents and its antioxidant potential
  – The drug companies should employ standard operation procedures in mangosteen plantation for xanthone production
  – In order to get standardized drug/jamu/herbal/health products
Conclution

• Research on the effects of xanthone on human healths is very importants
  – Is a high ORAC (antioxidants test) on xanthone good for human health? It should be proven.
  – Promotion of the herbal property should based on scientific evidence

• Consumer believe that herbal from mangosteen fruit have superior health benefits, but they are also concerned with the taste of the product
Thank you for your attention