Canarium odontophyllum fruit as a rich source of nutritionally important minerals and beneficial trace elements

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Canarium odontophyllum Miq. as one of the underutilized fruits grown in peat soil are consumed by the local community in Sarawak and as such, could posed health problem due to its high content of mineral and heavy metals. The present study therefore, was objectively done to identify the level of the toxic metals and trace elements in C. odontophyllum fruit using inductive coupled plasma-mass spectrometry. The trace element found in highest concentration was molybdenum at 38.22 ppm whereas magnesium and calcium were the nutritionally important elements found in considerably high level of 32.93 ppm and 24.66 ppm respectively. The rest of the thirteen elements were either not detected or found within low level. Despite the low arsenic level at 0.015 ppm, Pb and Cd were the heavy metals not detected in C. odontophyllum fruit. As conclusion, C. odontophyllum fruit has huge potential to be a rich source of nutritional trace elements with either very low or undetectable level of non-essential trace elements and toxic metals. This finding provides awareness of the safety consumption of this underexploited fruit and future prospect should focus on developing the fruit of Canarium odontophyllum as supplement in diseases of mineral deficiency.

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1. Introduction

1.1 Metal and human health
Conventionally, previous risk assessments have focused primarily on the effects of high doses of chemicals, which ultimately may induce toxicity. The presence of heavy metals in fruits and vegetables cannot be underestimated as these foodstuffs are important components of human diet (Singh et al., 2011). Among all the heavy metals, arsenic, cadmium, mercury and lead, are of particular concern in terms of food safety and public health (Hutton, 1987). However, for several metals which are essential to life, harmful effects also occur at very low level of intake (da Silva et al., 2005). Trace elements are vital for human body to maintain normal, yet complex physiological functions related to body’s growth & development. According to WHO (2002), the trace elements which are regarded as essential for human health are copper, zinc, iron, chromium, molybdenum, selenium, cobalt, manganese and iodine. A second group of elements which are classified as “probably essential for humans” are silicon, nickel and boron whereas the third group which has no known biological function in human are beryllium, lithium, antimoniy, strontium, thallium and vanadium.

1.2 Canarium odontophyllum
Canarium odontophyllum Miq. which belongs to family Burseracea is locally known as
‘dabai’ in Malaysia and ‘Sibu olive’ in Sarawak, where it is a seasonal fruit indigenous to this part of East Malaysia. *C. odontophyllum* is dioecious with male and female flowers borne on different trees. The fruits are blue-black in colour when ripe, oblong in shape and have a thin, edible skin. The flesh is either white or yellow which covers a large three-angled seed. The flavour is unique with thick and oily texture like an avocado fruit. Recent study has showed that *C. odontophyllum* fruit, especially the skin, is the major source of antioxidant due to its high content of phenolic compounds (Shakirin et al., 2010). In addition to this, *C. odontophyllum* fruit is also a good source of unsaturated fatty acids and thus, has the potential to be developed as healthy cooking oil (Azrina et al., 2010).

*C. odontophyllum* fruit is very nutritious with high content of lipid, carbohydrate, protein and mineral such as potassium, phosphorus, calcium, and magnesium (Hoe and Siong, 1999). Ding and Tee (2010) reported that *C. odontophyllum* fruit was very nutritious, with high energy (339 kcal/100g edible portion), fat (26.2%), carbohydrate (22.1%), protein (3.8%), crude fibre (4.3%), ash (2.3%), potassium (810mg/100g edible portion), calcium (200mg/100g edible portion), magnesium (106mg/100g edible portion), phosphorus (65mg/100g edible portion) and iron (1.3mg/100g edible portion). To the best of our knowledge, no past researches have been conducted to investigate the level of other important trace elements such as copper, zinc, chromium, molybdenum, cobalt, manganese and nickel as well as the heavy metals in *C. odontophyllum* fruit. Keeping in mind the health-promoting properties and high nutritional benefits of *C. odontophyllum* fruit, the present study was carried out to establish data on the essential and toxic element in this unique local fruit.

2. Materials and Methods

2.1 Instrument and working parameters

The trace and minor elements content in the samples were determined using inductive coupled plasma mass spectrometry (ICP-MS ELEAN 9000) (PerkinElmer, Sciex USA). The ICP-MS was set with the condition as stated in Table 1.

2.2 Source of samples

The fresh *C. odontophyllum* fruits were purchased from a local market in Sarawak, Malaysia in October 2012 and stored in a ventilated packing bag at a temperature of 4°C. The initial moisture content of *C. odontophyllum* fruit was determined by measuring its initial and final weight using the hot-air chamber at 120°C until constant weight was obtained (Meziane, 2011). The average initial moisture content of the fresh *C. Odontophyllum* fruit was obtained to be 63.33% w.b. (Basri et al., 2012).

2.3 Standard solution

Multielement stock solution Cal. No. 3 from PerkinElmer was used in this study, which comprised 1000 mg/l of each element. Analytical calibration standards were prepared over the range 0 µg/l to 500 µg/l for all the elements tested.

2.4 Samples preparation

All the samples were processed using acid digestion method based on modified standard procedure of EPA 200.3 (EPA 1996). Samples were rinsed using deionized water to get rid all the contaminants. A total of 5 g of the samples were placed in the 50 ml beaker and 10 ml of concentrated nitric acid was added.

The mixture was heated on the hot plate until the color of the solution changed to brown. The sample was then cooled, before 10 ml of nitric acid was added. It was again heated until the solution turned brown once again. The samples were then reheated until the volume was reduced to between 5 ml to 10 ml. After the mixture was evaporated to the desired volume, 2 ml of hydrogen peroxide solution was added. The process of adding hydrogen peroxide solution, heating and cooling were repeated until the sample solution turned clear.

Next, the samples were cooled before 2 ml of hydrochloric acid was added and were then reheated until the volume became 10 ml. Finally, the sample solutions were diluted with deionized water until the volume eventually reached 100 ml.

<table>
<thead>
<tr>
<th>Table 1: Operating conditions for ELAN 9000 ICP-Mass Spectrometer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RF Power</strong></td>
</tr>
<tr>
<td><strong>Sampler Diameter</strong></td>
</tr>
<tr>
<td><strong>Sample skimmer cone</strong></td>
</tr>
<tr>
<td><strong>Nebulizer</strong></td>
</tr>
<tr>
<td>(Mainhard)</td>
</tr>
<tr>
<td><strong>Peristaltic pump</strong></td>
</tr>
<tr>
<td><strong>Argon</strong></td>
</tr>
<tr>
<td><strong>plasma</strong></td>
</tr>
<tr>
<td><strong>Nebulizer flow</strong></td>
</tr>
<tr>
<td><strong>Spray chamber</strong></td>
</tr>
</tbody>
</table>
Table 2: Result of analysis for quantitative elements in C. odontophyllum fruit

<table>
<thead>
<tr>
<th>Sample</th>
<th>Ca (ppm)</th>
<th>Mg (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>32.96</td>
<td>23.12</td>
</tr>
<tr>
<td>2</td>
<td>32.90</td>
<td>26.21</td>
</tr>
<tr>
<td>Average</td>
<td>32.93</td>
<td>24.66</td>
</tr>
</tbody>
</table>

Table 3: Result of analysis for trace elements in C. odontophyllum fruit

<table>
<thead>
<tr>
<th>Sample</th>
<th>Fe (ppm)</th>
<th>Zn (ppm)</th>
<th>Mn (ppm)</th>
<th>Mo (ppm)</th>
<th>Cu (ppm)</th>
<th>Ni (ppm)</th>
<th>Co (ppm)</th>
<th>Cr (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.98</td>
<td>0.24</td>
<td>0.26</td>
<td>40.68</td>
<td>0.18</td>
<td>0.08</td>
<td>0.002</td>
<td>0.15</td>
</tr>
<tr>
<td>2</td>
<td>0.55</td>
<td>0.21</td>
<td>0.27</td>
<td>35.75</td>
<td>0.19</td>
<td>0.04</td>
<td>0.001</td>
<td>0.05</td>
</tr>
<tr>
<td>Average</td>
<td>0.765</td>
<td>0.225</td>
<td>0.265</td>
<td>38.215</td>
<td>0.185</td>
<td>0.06</td>
<td>0.0015</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Table 4: Result of analysis for ultra-trace elements in C. odontophyllum fruit

<table>
<thead>
<tr>
<th>Sample</th>
<th>Be (ppm)</th>
<th>Li (ppm)</th>
<th>Sb (ppm)</th>
<th>Sr (ppm)</th>
<th>Ti (ppm)</th>
<th>V (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.92</td>
<td>0.40</td>
<td>0.00</td>
<td>0.01</td>
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<tr>
<td>2</td>
<td>0.00</td>
<td>0.00</td>
<td>0.42</td>
<td>0.46</td>
<td>0.00</td>
<td>0.02</td>
</tr>
<tr>
<td>Average</td>
<td>0.00</td>
<td>0.00</td>
<td>0.67</td>
<td>0.43</td>
<td>0.00</td>
<td>0.015</td>
</tr>
</tbody>
</table>

Table 5: Result of analysis for toxic elements in C. odontophyllum fruit

<table>
<thead>
<tr>
<th>Sample</th>
<th>As (ppm)</th>
<th>Pb (ppm)</th>
<th>Cd (ppm)</th>
<th>Acceptable limit (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>0.02</td>
<td>0.00</td>
<td>0.00</td>
<td>0.13</td>
</tr>
<tr>
<td>Average</td>
<td>0.015</td>
<td>0.00</td>
<td>0.00</td>
<td>0.24</td>
</tr>
</tbody>
</table>

3. Results and Discussion

The concentration of 19 elements were determined in the fleshy mesocarp of C. odontophyllum fruit using ICP-MS and the results of elemental analysis are presented based on their classification of quantitative elements (Ca and Mg) in Table 2, trace elements (Fe, Zn, Mn, Mo, Cu, Ni, Co, Cr) in Table 3, ultra-trace elements (Be, Li, Sb, Sr, Ti, V) in Table 4 and the toxic elements which comprised the heavy metals (As, Cd and Pb) in Table 5.

3.1 Analysis of quantitative elements content in C. odontophyllum fruit

The nutritional benefit of C. odontophyllum fruit is clearly demonstrated in this study by considerably high level of calcium at 32.93 ppm and magnesium at 24.66 ppm. This is in agreement with (Ding and Tee., 2010). The high content of molybdenum in C. odontophyllum fruit could be due to its dependency on the amount of the nutrient in the soil in which they are cultivated. (Tsongas et al., 1980) has reported that most fruits and animal products are low in molybdenum. The high content of molybdenum in C. odontophyllum fruit can meet more than twice the daily-required amount. Human body needs more calcium and magnesium than any other minerals because they are the primary building blocks of bones, teeth and muscles (Hamad and Al-Jamaien., 2010). Other fruits which were reported to have the highest level of calcium and magnesium are the walnut cultivated in Romania (Cosmulescu et al., 2009) and wood apple from Bangladesh (Tariqul Islam Shajib et al., 2013).

3.2 Analysis of beneficial trace elements in C. odontophyllum fruit

The trace element found in highest concentration C. odontophyllum fruit was molybdenum at 38.22 ppm. Molybdenum is an essential element in human nutrition, which is involved in many important biological processes, including development of the nervous system, waste processing in the kidneys, and energy production in cells (Rajagopalan., 1988). In view of its dietary importance, it is sold as a dietary supplement in the United States. The molybdenum level in the fruit of C. odontophyllum is considered the highest out of all 19 elements studied. This is quite unexpected because according to (Tsengas et al., 1980), most fruits and animal products are low in molybdenum. The high content of molybdenum in C. odontophyllum fruit could be due to its dependency on the amount of the nutrient in the soil in which they are cultivated.
are grown (Pennington et al., 1987). According to (Baljinnyam et al., 2014) on the study of some medicinal plants from Mongolia, the variation in elemental concentration is mainly attributed to the differences in botanical structure, as well as in the mineral composition of the soil in which the plants are growing. There is also a possibility that C. odontophyllum fruit has high affinity to absorb molybdenum than any other minerals from the soil in which it is grown just as how Oryza sativa was known to effectively absorb arsenic from soil or water than most other plant species (Zhao., 2009). Although the Tolerable Upper Intake Level (UL) for molybdenum in adults was set at 2 mg per day (IOMFNB, 2001; Garrison and Somer., 1995), the extremely high level of molybdenum in C. odontophyllum fruits will not cause any harmful effects associated with high molybdenum level in human such as gout, anaemia and symptoms of copper deficiency. This is because of the rapid renal clearance of the majority of ingested molybdenum, which will likely prevent deleterious effects in the event of high intake (Molybdenum Monograph, 2006).

Besides manganese and zinc, iron also an important trace element which is essential to human in trace amount to transport oxygen to all parts of our body (Dallman, 1986). Our finding showed that iron is detected at 0.76 ppm in the fruit of C. odontophyllum. Iron is an integral part of many proteins and enzymes that maintain good health. It is also essential for the regulation of cell growth and differentiation (Andrews, 1999).

The rest of the 4 trace elements namely Cu, Cr, Ni and Co was found in low concentration at 0.185 ppm, 0.10 ppm, 0.006 ppm and 0.002 ppm, respectively. In spite of the fact that cobalt is essentially a nutritionally important trace element, our findings revealed that its concentration is very low compared to the less beneficial ultra-trace metals such as antimony and strontium. This is probably because the salt of cobalt is relatively insoluble in water (WHO, 2006). This is supported by (Hete et al, 2012), that even when plants grow on cobalt-contaminated soils, they will accumulate very small particles of cobalt, especially in the parts of the plant we eat such as fruit and seed.

3.3 Analysis of ultra-trace elements content in C. odontophyllum fruit
Out of six ultra-trace elements analysed in the study, antimony and strontium were present in C. odontophyllum fruit at 0.67 ppm and 0.43 ppm, respectively. This finding also demonstrated that metals with no known beneficial effect were either not detectable (beryllium, thallium, lithium) or was found within very low level (vanadium). These are the non-essential elements which have no known function in living organisms (Lalor., 1995). However the presence of Sb and Sr at concentration lower than that of Fe in the fruit of this medicinal plant could be attributed to the fact that these elements are moderately water soluble and are therefore can be readily taken up by roots of the plant (Howe et al., 2005).

3.4 Analysis of of toxic metals content in C. odontophyllum fruit
The content of heavy metal in C. odontophyllum fruit are shown in Table 5. With reference to acceptable limit values, the level of arsenic was more than 100 times lower and hence, indicated that this fruit is safe for human consumption. (FDA., 2012) has released a report on 19 September 2012, that arsenic has been detected in rice. Since then, the arsenic issue has become a serious concern for all food production. Many rice-based foods and some fruit juices have arsenic levels much higher than are allowed in drinking water of 10 ppb (Consumer Reports., 2012). Long-term exposure to high levels of arsenic is associated with higher rates of skin, bladder, and lung cancers, as well as heart disease (Puttia and Guo, 2011). However, the level of arsenic in the fruit of C. odontophyllum is too low to pose a health hazard whereas lead and cadmium were not detected at all.

Conclusion
This findings report that C. odontophyllum fruit has huge potential to be a rich source of nutritionally important minerals which are calcium and magnesium that the human body needs and high level of the beneficial trace elements such as molybdenum and iron. In addition, this underutilized local fruit was shown to have either very low concentration or undetectable level of non-essential trace elements and toxic metals.

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Disclosures

The authors do hereby declare that there are no conflicts of interest to this research.

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