The Potential of Water Spinach (*Ipomoea Aquatica* Forsk.)
as A Functional Food: A Mini Review

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Abstract

Water spinach (*Ipomoea aquatica* Forsk.) is one of the many crops cultivated by farmers in Indonesia. This plant is very popular as vegetables in various processed foods. However, until now there has not been much development into a functional food. This paper aims to review various literature from scientific articles related to the potential of *I.aquatica* as a functional food. To become functional food, food must contain bioactive compounds that have the ability to maintain and improve health status. Phytochemically, *I.aquatica* contains various secondary metabolites such as flavonoids, carotenoids, tannins, and steroids. The main flavonoids found in *I.aquatica* are quercetin and quercetin 3-O-monoglycosides which can act as antioxidants. Meanwhile, carotenoids contained in *I.aquatica* are β-carotene, lutein and violaxanthin which have the potential as antioxidants and antidiabetic. Apart from secondary metabolites, *I.aquatica* has laxative effects from its dietary fiber. Therefore, the potential of *I.aquatica* as a functional food ingredient is very large.

Keywords: water spinach, functional food

1. Introduction

The unhealthy lifestyle such as consume excess sugar, less physical activity, deficiency of vitamin D, smoking and pollution will effect on diabetes mellitus and cardiovascular disease (Su et al., 2011; O’Keefe et al., 2016). Cardiosvascular disease is the leading cause of mortality in developed countries (Roger et al., 2015). Epidemiological studies indicated that the frequent consumption of fruits and vegetables significantly help to reduce risk of cancer and cardiovascular disease (Song et al., 2010; Rodriguez-Mateos et al., 2014;). Beside that, now there is a new trend and great interest from consumer to maintain health status with consumption of functional food products (Betoret et al., 2011).
Functional food appears as a quite unique concept that deserves a category of its own and different from nutraceutical, pharmafood, medifood, vitafood and does not include dietary supplements. Functional foods are and must be foods, not drugs (Roberfroid, 2002). The feature of functional food is contain bioactive compounds as active ingredient (De Boer et al., 2016). From the bioactive compounds, functional foods will have health claim based on scientific evidence. Bioactive compounds in many fruit and vegetables were phenolic compound and other secondary metabolites (Wiczkowski et al., 2013).

As a tropical country, Indonesia is very rich in natural resources in the form of fruits and vegetables. One of the vegetables which many cultivated is water spinach (*Ipomoea aquatica* Forsk.). *I.aquatica* is an edible and floating plant in water and include in Convolvulaceae family. It has hollow stems and arrowhead shaped leaves of about 15 cm long and 2 cm wide, and can grow up to 3 cm (Lin et al., 2012). During this time, *I.aquatica* is used as a phytoremediation agent to absorb various heavy metals such as lead (Chanu and Gupta, 2016) and chromium (Chen et al., 2010).

Previous study reported that it contains significant levels of flavonoid, dietary fiber, minerals, carotenoids, chlorophylls, vitamins, and essential amino acids (Huang et al., 2005; Deng et al., 2013). Based on the compound content, so it can be state that *I.aquatica* has the potential to be developed as a functional food ingredient.

**Nutritional Composition**

Various studies have reported the nutritional composition in *I.aquatica* extract, both major and minor component (table 1).

Lawal et al (2015) also carried out 1H NMR analysis on ethanol extract of I.aquatica. The results of his analysis were β-glucose, α-glucose, sucrose, alanine, formic acid, maleic acid, fatty acid, rutin, glutamic acid, citric acid, epicatechin, choline, malic acid, protocatechuic acid, D-hydroxy benzoic acid, leucine, acetic acid, and gamma-aminobutyric acid.

**Bioavability and Health Benefit of Bioactive Compounds in Ipomoea aquatica**

*I.aquatica* belongs to the convolvulaceae family which is widely grown in tropics and subtropics area (Lawrence, 1951). This plant grows floating on the water with a root length...
of 15-40 cm, long leaf with a size 3-4 cm and one genus with I.reptans, I.leari, and I.crassicaulis (Suratman et al., 2000). Phenolic compounds are constituted in one of the biggest and widely distributed groups of secondary metabolites in plants (Scalbert and Williamson, 2000) and also in *I.aquatica*.

<table>
<thead>
<tr>
<th>Component</th>
<th>Content</th>
</tr>
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<tbody>
<tr>
<td>dry matter content</td>
<td>8.3 %(^a); 8.5 %(^b)</td>
</tr>
<tr>
<td>β-carotene</td>
<td>(1890 \pm 58 \mu g/100 \text{g})(^a)</td>
</tr>
<tr>
<td>lutein</td>
<td>(4780 \pm 68 \mu g/100 \text{g})(^a)</td>
</tr>
<tr>
<td>xanthophylls</td>
<td>(3420 \pm 144 \mu g/100 \text{g})(^a)</td>
</tr>
<tr>
<td>vitamin A activity</td>
<td>(158 \pm 5 \mu \text{g RAE/100 g})(^a)</td>
</tr>
<tr>
<td>total phenolic</td>
<td>(2.46 \pm 0.08 \text{mg GAE/g DW})(^b)</td>
</tr>
<tr>
<td>total chlorophyll</td>
<td>(25.01 \pm 5.30 \mu \text{g/g DW})(^b)</td>
</tr>
<tr>
<td>total carotene</td>
<td>(2.11 \pm 0.03 \text{mg/g DW})(^b)</td>
</tr>
<tr>
<td>total dietary fiber</td>
<td>(41.2%)(^c)</td>
</tr>
<tr>
<td>soluble fiber</td>
<td>(20.9%)(^c)</td>
</tr>
<tr>
<td>hemicellulose</td>
<td>(4.9%)(^c)</td>
</tr>
<tr>
<td>cellulose</td>
<td>(14.4%)(^c)</td>
</tr>
</tbody>
</table>

\(^a\)Kidmose et al., 2006; \(^b\)Gunathilake & Ranaweera, 2016; \(^c\)Wang et al., 1991

RAE : retinol activity equivalents; GAE : gallic acid equivalents; DW : dry weight

**Flavonoids**

Flavonoids are a group of polyphenolic compounds, diverse in chemical structure and characteristics (Xiao et al., 2011). They occurred mainly in fruit, vegetables, nuts, seeds, and flowers and are generally present in plants as glycosides. The effectiveness of flavonoids depends on preserving their stability, bioactivity, and bioavailability during handling, extraction and processing (Galanakis, 2018).

Glycosides of the flavonols kaempferol and quercetin, especially 3-*O*-glucosides and 3-*O*-rutinosides are characteristics constituents in the Convolvulaceae family (Eich, 2008). The main flavonoids found in *I.aquatica* are quercetin and quercetin 3-*O*-monoglycosides which can act as antioxidants (Wirasutisna et al., 2012). The cardioprotective effects such as diets are often attributed to their phytochemical content, in particular, to the flavonoids they contain.
Epidemiological studies showed that the daily intake of dietary flavonoids may have prevent the development of atherosclerosis is referred to as endothelial dysfunction (fig.2). Intracellular Ca^{2+} is a key regulator of many cellular process (Fan et al., 2014). The most important properties of Ca^{2+} signalling are the promiscuity with respect to its effector systems and its autoregulation (Petersen et al., 2005). Low-density lipoprotein (LDL) is known to initiate atherosclerotic plaque formation. Flavonoid such as quercetin can be effective in LDL inhibition under physiological conditions (Thilakarathna et al., 2013).

Flavonoids also have the ability to inhibit platelet activation (Choi et al., 2015). The platelet adhesion response is necessary for the process of hemostasis. Platelets play a key role in many physiological functions especially in hemostasis and wound healing processes in order to maintain the integrity of the circulatory system. Activated platelet release cytokines and chemokines which modulate the immune response and, in some cases of hyperactivation, they could be associated to the pathogenesis of inflammatory disease (Faggio et al., 2017). Extract of *I.aquatica* also has been reported to possess a hypoglicemic effect on diabetic rats as well as type 2 diabetes mellitus patients (Malalaviddhane et al., 2000).
Carotenoids

Carotenoids are the large group of naturally occurring pigments that are found in plants, algae and microorganism. Green leafy vegetables are a rich source for carotenoids (Kao et al., 2013). Carotenoids are bioactive compounds in human diet with a multifaceted role in redox mechanism. β-carotene, violaxanthin and lutein are the parts of carotenoid in *I. aquatica*. The content of violaxanthin, β-carotene and lutein in water spinach were 2.1 ± 0.5, 4.3 ± 0.9 and 9.5 ± 1.2 µg/g (fresh weight), respectively (Fu et al., 2011).

As free radical scavengers, carotenoids react with reactive oxygen/nitrogen species (ROS/NOS) (Barros et al., 2018). Violaxanthin is very effective to inhibit lipid peroxidation and ABTS cation radical than β-carotene and lutein. But β-carotene have high radical scavenging on DPPH radicals than violaxanthin and lutein (table 2). It can be seen from the figure 3 that the scavenging activity of β-carotene which has two β-ionone rings.
Radical DPPH properly quenched by carotenoids via hydrogen abstraction at the allylic position in the β-ionone ring (C-4)

Table 2 The IC_{50} values of the three carotenoids (Fu et al., 2011).

<table>
<thead>
<tr>
<th>Compounds</th>
<th>IC_{50} values for the free radical scavenging assays (µg/mL)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DPPH radicals</td>
<td>ABTS cation radicals</td>
</tr>
<tr>
<td>β-carotene</td>
<td>4.45</td>
<td>5.85</td>
</tr>
<tr>
<td>lutein</td>
<td>7.54</td>
<td>3.54</td>
</tr>
<tr>
<td>violaxanthin</td>
<td>8.77</td>
<td>3.38</td>
</tr>
</tbody>
</table>

\[ \text{(a)} \]

\[ \text{(b)} \]

\[ \text{(c)} \]

Fig. 3 (a) β-carotene, (b) lutein, (c) violaxanthin.

**Dietary Fiber**

In addition to secondary metabolites, *I.aquatica* is also rich in dietary fiber (Candlish et al., 1987). Dietary fiber plays an essential role in everyday life owing to their associated health benefits, especially in the prevention of diabetes mellitus and obesity management (Arun et al., 2017; Baldassano et al., 2018). Soluble and insoluble fiber have ability to adsorb glucose. Based on the table 1, *I.aquatica* contain 41.2% of total dietary fiber. Beside that, *I.aquatica* is good source of peroxidase enzymes which used in pharmaceuticals
(Rusdi et al., 2014). Peroxidases in plant commonly found in the cell walls, vacuoles, cell organel transport, and also on the rough endoplasmic reticulum.

The development of functional food has increase in many innovation such as functional food based on local food as breakfast for overweight (Darawati et al., 2016) until fortified yoghurt with vitamin D to prevent diabetes (Mostafai et al., 2012). The stability of secondary metabolites were affected by many factor such as heat, light, pH, and processing technique. So, the development techniques of functional foods must be adapted to the characteristics of the compounds.

2. Conclusion

Water spinach (Ipomoea aquatica Forsk.) contains many bioactive compound such as flavonoid, carotenoids, chlorophyll, and dietary fiber. These compound have physiological function for body health and can be the basis the development of functional food product.

3. Acknowledgment

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