Pigment and Nutritional Value of *Spirogyra* spp. in Sakon Nakhon, Nakhon Phanom and Mukdahan Provinces

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Abstract

Edible freshwater macroalgae, *Spirogyra* spp. (Division Chlorophyta) are normally found in natural water sources and local markets, and are commonly consumed as a traditional type of food in north-eastern Thailand. *Spirogyra* spp. has been found to possess high nutritional value and contain various bioactive compounds. The focus of this research study was to examine the pigments and to assess the nutritional value of the *Spirogyra* spp. samples collected from 12 water resources of Sakon Nakhon, Nakhon Phanom and Mukdahan Provinces. The samples collected from each sampling site were dried and the pigment quantity and nutritional value were analyzed. The highest quantity of chlorophyll *a*, *b* and the carotenoid content were recorded at 4.067, 1.716 and 1.209 mg/g of cell dry weight, respectively. The samples were tested for their basic nutritional value and the highest values of ash, fat, moisture, protein, carbohydrate and energy were recorded at 17.37, 5.51, 14.90, 22.77, 67.13 g/100g and 363 kcal/100g, respectively. Thus, the results of this study support the possibility of using *Spirogyra* spp. as a food supplement and antioxidant products.

Keywords: *Spirogyra*, chlorophyll, carotenoid, nutritional value
1. Introduction

Algae is very important and well-known as the primary producer of food web in aquatic ecosystems, as it produces oxygen via the photosynthesis pathway [1]. Algae also has many beneficial uses including as a bioindicator or as a biofuel, to purify wastewater, as a lubricant, fertilizers, cosmetics, nutraceutical, animal feed and processed food [2, 3]. Most edible algae are recognized as seaweed, either as brown or red algae. In terms of freshwater algae, the edible algae are planktons which can be cultivated to produce a variety of products and macroalgae [4, 5]. The production of macroalgae biomass are mainly produced in Asian countries such as China, the Republic of Korea, Philippines, Japan and Indonesia [6].

Freshwater macroalgae are used as ingredients in traditional food in northern and north-eastern areas of Thailand. It is often found in natural water sources, especially in rural areas and local markets. There are about 4 genera of well-known edible macroalgae; *Spirogyra* spp., *Cladophora* spp., *Microspora* spp. and *Nostochopsis* spp. These are widely used in a number of food products and supplements, and have been recognized for being medicinal plants [5]. *Spirogyra* spp. is unbranched filamentous green algae in the order Zygnematales due to the spirally coiled chloroplast. It is commonly found in stagnant or slow running water [4]. These algae also have high nutritional compositions (carbohydrates, proteins, fats, vitamins etc.) [5, 7] and are known to possess bioactive compounds such as those that display antimicrobial and antifungal properties [8-10]. They also are known to inhibit the absorption and synthesis of cholesterol [11], inhibit gastric ulcer formation [12], and to possess immunostimulation [13], antimutagenic and antioxidant properties [14].

In terms of its macroalgae pigments; chlorophyll is composed of a porphyrin ring which is an essential structure for antioxidant activity. Additionally, the most common algal carotene is the β-carotene, which is a precursor of vitamin A and is called provitamin A [15]. Palace et al. [16] reported that vitamin A, carotenoids and provitamin A are antioxidants that can be effective in inhibiting the development of heart disease. Most studies of the nutritional values and pigments of *Spirogyra* spp. are evaluated from samples in northern areas such as Phrae [7] and Chiang Mai province [17].

The main objective of this research was to study the pigments of *Spirogyra* spp. in certain water sources of Sakon Nakhon, Nakhon Phanom and Mukdahan Provinces. Furthermore, the nutritional value of edible macroalgae were studied. The results of this study can be used to promote the potential of natural resources that can be used as food or nutritional supplements in the future.
2. Materials and Experiment

Spirogyra spp. samples were collected from 7 sites in Sakon Nakhon Province, 2 sites in Nakhon Phanom Province and 3 sites in Mukdahan Province over a two-year period from 2016 to 2018. The samples were collected from a variety of substrates, i.e. rocks, cobbles and tree branches that were immersed in the water. The harvested macroalgae were stored in plastic boxes at low temperatures for identification in the laboratory. The morphology identification of algae was done through the use of certain relevant documents such as those by John et al. [18]. The samples were then photographed using an Olympus Normaski microscope.

The samples were washed and dried at 45 °C for 48 hours and then ground. The dried powder of the algae was measured 3 types of pigments and repeated in triplicate. The chlorophyll a and b samples were analyzed according to the methanol extraction method [19]. Carotenoids were analyzed according to the methods of Punyoyai [19].

The nutritional value; ash, fat, moisture and protein contents were determined by AOAC [20]. Carbohydrate and energy contents were determined by a compendium of method for food analysis [21].

3. Results and Discussion

3.1 Spirogyra spp. diversity

The macroalgae samples obtained from 12 sampling sites in Sakon Nakhon, Nakhon Phanom and Mukdahan Provinces was recorded as 12 species of Spirogyra spp. There are different in diameter of filament, number of chloroplast and number of turn of chloroplast per cell (Table 1). The Spirogyra spp. were most commonly present during the rainy and cold seasons and the quantities were found to be sampling site-dependent. The findings were similar to those of the study Kanajan and Chueduengqi [22] at Kham Hom Waterfall, in Sakon Nakhon Province and Moosin [23] at Huay Tham Khae Reservoir, Ubon Ratchathani Province. Theses researchers revealed that Spirogyra spp. was the dominant macroalgae and occurred in the rainy and cold seasons. The reason that Spirogyra spp. was found to be the dominant genera of edible macroalgae is that it is present in a wide range of habitats, where it is typically attached to stable substratum. However, it can also occur as free-floating mats and has also been found in standing or slow-running water [1, 18].
Table 1 Diversity of *Spirogyra* spp. in Sakon Nakhon, Nakhon Phanom and Mukdahan Provinces

<table>
<thead>
<tr>
<th>Samples</th>
<th>Location</th>
<th>Light micrographs of macroalgae</th>
</tr>
</thead>
<tbody>
<tr>
<td>SK1</td>
<td>Irrigation canal, Dong Mafai, Mueang Sakon Nakhon, Sakon Nakhon</td>
<td><img src="image" alt="Spirogyra sp.1" /></td>
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<tr>
<td>SK2</td>
<td>Nam Phung, Mueang Sakon Nakhon, Sakon Nakhon</td>
<td><img src="image" alt="Spirogyra sp.2" /></td>
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<tr>
<td>SK3</td>
<td>Huai Diak, Mueang Sakon Nakhon, Sakon Nakhon</td>
<td><img src="image" alt="Spirogyra sp.3" /></td>
</tr>
<tr>
<td>SK4</td>
<td>Nam Un, Nong Lat, Mueang Sakon Nakhon, Sakon Nakhon</td>
<td><img src="image" alt="Spirogyra sp.4" /></td>
</tr>
<tr>
<td>Samples</td>
<td>Location</td>
<td>Light micrographs of macroalgae</td>
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</tr>
<tr>
<td>SK5</td>
<td>Nam Phung Bridge, Tao Ngoi, Sakon Nakhon</td>
<td><img src="image" alt="Spirogyra sp.5" /></td>
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<tr>
<td>SK6</td>
<td>Ban Pung, Na Tong Watthana, Phon Na Kaeo, Sakon Nakhon</td>
<td><img src="image" alt="Spirogyra sp.6" /></td>
</tr>
<tr>
<td>SK7</td>
<td>Si Songkhram river, Ban Non Sang Thong, Ban Muang, Sakon Nakhon</td>
<td><img src="image" alt="Spirogyra sp.7" /></td>
</tr>
<tr>
<td>NP1</td>
<td>Pond, Pla Pak, Nakhon Phanom</td>
<td><img src="image" alt="Spirogyra sp.8" /></td>
</tr>
</tbody>
</table>
### Samples

<table>
<thead>
<tr>
<th>Samples</th>
<th>Location</th>
<th>Light micrographs of macroalgae</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP2</td>
<td>Songkram river, Don Toei, Na Thom, Nakhon Phanom</td>
<td></td>
</tr>
<tr>
<td>MK1</td>
<td>Phu Pasan, Ban Kho, Khamcha-I, Mukdahan</td>
<td></td>
</tr>
<tr>
<td>MK2</td>
<td>Nong Khamtalad, Lao Sang Tho, Khamcha-I, Mukdahan</td>
<td></td>
</tr>
<tr>
<td>MK3</td>
<td>Nong Phue, Chanot, Wan Yai, Mukdahan</td>
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3.2 Analysis of *Spirogyra* spp. pigments

In Fig. 1, the amount of chlorophyll *a* of *Spirogyra* spp. obtained from 12 sampling sites was found to be in the range of 0.718-4.067 mg/g of cell dry weight. The highest chlorophyll *a* quantity was found in SK1 and the lowest quantity...
was found in SK2. The amount of chlorophyll b was found in the range of 0.056-1.716 mg/g of cell dry weight. The highest amount was recorded in SK5 and the lowest amount was found in SK2. A comparison of the chlorophyll quantities of chlorophyll a and b revealed that there was a higher quantity of chlorophyll a when compared to chlorophyll b. According to Pal and Choudhury [15], it was reported that chlorophyll a is present in all forms of autotrophic algae, while other types of chlorophyll have more limited distribution and are known to function as accessory photosynthetic pigments. Chlorophyll b functions as a light-harvesting pigment that transfers absorbed light energy to chlorophyll a. The findings of this analysis are similar to those of the study of Thamprawat and Srikanchai [24] who reported that chlorophyll a quantity was higher than that of chlorophyll b and similar to the quantity of chlorophyll.

In freshwater algae, the major pigment is chlorophyll, so it is present in higher quantities than other pigments. In this study, Spirogyra spp. were found to possess a range of carotenoids between 0.126-1.209 mg/g of cell dry weight. The highest quantity was found in SK7 and the lowest was recorded in SK2. The quantity of carotenoids in most samples (except for the samples collected from sites SK6, SK7 and NP2) was similar to the quantity of carotenoids present in Spirogyra neglecta (Hassall) Kützing obtained from Suan Khuean Sub-district, Muang, Phrae Province at 0.399 mg/g of cell dry weight [19]. Furthermore, it was found that the SK1, SK5 and SK7 samples which found high chlorophyll quantity, also found large band of chloroplast as shown in Table 1.

![Figure 1 Chlorophyll a, b and carotenoids in Spirogyra spp. collected from Sakon Nakhon, Nakhon Phanom and Mukdahan Provinces](image-url)
3.3 Nutritional value of Spirogyra spp.

In this study (Fig. 2), the Spirogyra spp. obtained from 12 sampling sites revealed different levels of nutritional value. In Sakon Nakhon Province, Spirogyra sp.2 (SK2), Spirogyra sp.4 (SK4) and Spirogyra sp.7 (SK7) reported having the highest levels of carbohydrates (67.13 g/100g), moisture (14.90 g/100g) and fat (5.51 g/100g), respectively. The Spirogyra sp.10 (MK1) and Spirogyra sp.12 (MK3) samples collected from Mukdahan Province showed the highest levels of protein (22.77 g/100g) and energy (363.61 kcal/100g). Additionally, Spirogyra sp.9 (NP2) was found to possess the highest level of ash (17.37 g/100g). The nutritional value of Spirogyra spp. in this study was similar to that of the samples of Spirogyra neglecta (Hassall) Kützing obtained from Suan Khuean Sub-district, Muang, Phrae Province, which were found to be 23.37 g/100g of protein, 5.54 g/100g of fat, 55.05 g/100g of carbohydrate and 363.58 kcal/100g of energy [7]. Notably, the protein content in the SK4 samples was much less than in the samples collected from Phrae Province. The potential for using Spirogyra spp. as a food ingredient or as a supplement is of significant interest because the protein content present in algae is the same as in meat and some samples were found higher than eggs [25]. The Ministry of Public Health [25] reported that eggs, catfish, pork and chicken reveal protein contents of 12.3, 23.0, 19.6, and 19.5 g/100g, respectively. Additionally, Spirogyra spp. also revealed carbohydrate and energy levels that were higher than meat as well, but lower than rice, wheat and oat [25].
4. Conclusions

The study of *Spirogyra* spp. diversity was done through the collection of samples from 12 water resources of Sakon Nakhon, Nakhon Phanom and Mukdahan Province. Twelve species of *Spirogyra* spp. were found. The period of time in which *Spirogyra* spp. was present in all sampling sites was during the rainy and cold seasons and the quantities were found to be site-dependent. All *Spirogyra* spp.
specimens were found to be higher in chlorophyll a quantities than chlorophyll b. The highest chlorophyll a, b and carotenoid contents were recorded as 4.067, 1.716 and 1.209 mg/g of cell dry weight, respectively. The samples were tested for 6 types of basic nutritional value. The values were found to be between 4.59-17.37 g/100g of ash, 2.47-5.51 g/100g of fat, 8.05-14.90 g/100g of moisture, 7.63-22.77 g/100g of protein, 48.79-67.13 g/100g of carbohydrate and 308.08-363.71 kcal/100g of energy. The possibility of using *Spirogyra* spp. as a food supplement was found because the nutritional value has been found to be equal to that of meat. Additionally, the pigment quantity of *Spirogyra* spp. has been identified as an effective antioxidant.

5. Acknowledgements

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6. References


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