High-Protein Crispy Snack from freshwater Algae : A New Plant-Based Protein Alternative

Saritwat Jiarapong[1]* and Theewara Talernglap[1]

Watcharaporn Saenna[1]

[1]Princess Chulabhorn Science High School Buriram, Satuek, Buriram 31150, Thailand

**E-mail: saritwatjiarapong@pcshsbr.ac.th*

Abstract

This research project aimed to develop a baked crispy snack using Spirogyra, a freshwater algae with high protein content, as the main ingredient. The objective was to create a healthier snack with higher nutritional value than conventional snacks, which are generally high in fat, low in protein, and contain many food additives. Spirogyra provides protein comparable to soybeans and some animal-based sources while also supplying vitamins, minerals, and dietary fiber. It is easy to cultivate, grows rapidly, and has minimal environmental impact, making it a promising resource for sustainable health food development. The product was formulated with Spirogyra as the primary ingredient and topped with roasted sesame seeds to enhance nutritional value while using health-conscious seasonings. The production process included raw material preparation, seasoning, baking, and packaging, followed by quality evaluation. Quality assessment focused on protein, fat, moisture, and ash content. The product contained 22.00±0.53 g of protein per 100 g, exceeding the target of at least 15.00 g per 100 g. The fat content was 2.70±0.28 g per 100 g, meeting the criterion of not exceeding 8.00 g per 100 g. The average moisture content after storage was 6.42±1.63 %, remaining below the 10% limit, while the average ash content was 16.91±0.35 %, indicating the total mineral content after ashing. The results demonstrate that the developed Spirogyra-based baked crispy snack successfully achieved the project objectives and hypotheses. The project also supports the Sustainable Development Goals (SDGs), particularly Goal 9, promoting innovation and sustainable industrialization, and Goal 12, encouraging sustainable consumption and production.

keywords : Plant-based protein, Spirogyra

Introduction

Nowadays, consumers are increasingly concerned about maintaining good health and choosing foods with high nutritional value, particularly foods that help reduce the risk of Non-Communicable Diseases (NCDs), such as cardiovascular disease, diabetes, hypertension, and obesity. Consuming foods that are high in protein and low in fat is considered one of the most effective approaches for preventing these diseases. However, most commercially available snack products are generally high in fat, low in protein, and contain large amounts of additives and preservatives, which may negatively affect long-term health. Consequently, the demand for healthier snack products with improved nutritional value has continued to grow in both Thailand and global markets.

One of the major food trends receiving increasing attention is plant-based protein, which is derived from natural sources, safe for consumption, and environmentally sustainable. Compared with animal-based protein production, plant-based protein requires fewer natural resources and has a lower environmental impact, making it an important alternative for promoting both human health and sustainability.

Spirogyra, a freshwater green algae commonly found in Thailand, especially in the northern and northeastern regions, has high nutritional value. It contains protein comparable to soybeans and some animal-based foods, while also providing vitamins, minerals, and dietary fiber. It grows rapidly, is easy to cultivate, requires minimal resources, and has low environmental impact. Although Spirogyra is traditionally consumed in local dishes such as *Kaeng Tao* and *Yum Tao*, it has not yet been widely developed into commercial healthy snack products despite the growing demand in the healthy snack market.

Therefore, this project aims to develop a high-protein crispy baked snack using Spirogyra as the main ingredient. Powdered Wolffia and roasted sesame seeds are incorporated to further enhance protein content while improving flavor, aroma, and texture. The product is formulated without harmful additives or chemical preservatives.

The production process controls the moisture content below 10% to maintain crispiness and extend shelf life. Product quality is evaluated through laboratory analysis of protein and moisture content, together with consumer satisfaction testing to assess nutritional value and sensory acceptance.

The expected outcome is a prototype healthy crispy snack with high protein content produced from locally available natural resources. The project aims to increase the value of Spirogyra, promote environmental and economic sustainability, and provide a foundation for the future development of innovative commercial health food products.

Methodology

Step 1: Preparation of Spirogyra

Dried Spirogyra was cleaned and soaked in clean water for 30 minutes, with the water changed every 15 minutes. The algae were

then boiled at 100°C for 5 minutes and allowed to cool before seasoning.

Step 2: Seasoning Preparation

A seasoning solution was prepared by mixing water, powdered Wolffia, and soy sauce until homogeneous. The boiled Spirogyra was then thoroughly mixed with the seasoning solution to ensure even coating

Step 3: Baking Process

The seasoned Spirogyra was spread into a thin layer on a baking tray lined with baking paper. The product was baked at 160°C for 25 minutes, during which roasted sesame seeds were sprinkled onto the surface. The temperature was then increased to 180°C, and the product was baked for an additional 5 minutes on each side to achieve a uniformly crispy texture.

Step 4: Packaging and Product Analysis

The finished product was packed in aluminum foil bags, flushed with nitrogen gas, and heat-sealed tightly. Protein content was analyzed according to the standard AOAC 981.10 method and fat content was analyzed the standard AOAC 920.39 method, while moisture content was determined using a moisture analyzer in order to evaluate product quality

Result and Discussion

Phase 1: The crispy Spirogyra algae product contained 22 g of protein per 100 g, which was nearly twice as high as general crispy seaweed products that contained 11.68 g of protein per 100 g. This result demonstrates the potential of Spirogyra as a highly nutritious plant-based protein source.

Table I: Protein Content in Crispy Algae Analyzed by AOAC 981.10

Times	Protein found in crispy algae (g/100g)
Time 1	21.9±0.53 (g/100g)
Time 2	22.40±0.53 (g/100g)
Time 3	21.34±0.53 (g/100g)
Average	22.00±0.53 (g/100g)

shows that the average protein content is 22.00±0.53 which exceeds the minimum target of 15.00 g/100 g.

Phase 2: The crispy Spirogyra algae product contained 2.70 g of fat per 100 g, which was substantially lower than the maximum criterion of 8.00 g per 100 g. This result indicates that the product meets the requirements for a low-fat food and may be a healthier snack option for consumers.

Table II: Fat Content in Crispy Algae Analyzed by AOAC 920.39

Times	Fat found in crispy algae (g/100g)
Time 1	2.97±0.28 (g/100g)
Time 2	2.48±0.28 (g/100g)
Time 3	2.49±0.28 (g/100g)
Average	2.70±0.28 (g/100g)

shows that the average fat content was 2.70±0.28 which did not exceed the maximum limit of 8.00 g/100 g.

Phase III: The moisture content of the crispy Spirogyra algae ranged from 6.04–6.74%, which was below the quality standard limit of 10%. This indicates that the baking process effectively reduced the moisture content to a suitable level for storage. Compared with commercial crispy seaweed snacks available on the market, which generally had lower and more consistent moisture levels, commercial products still showed greater consistency due to the use of industrial machinery capable of more precise temperature and time control.

Table III: Moisture Content in Crispy Algae Analyzed by Moisture Analyzer

Pieces	Moisture found in crispy algae (% M)
Piece 1	6.74±1.63 % M
Piece 2	6.04±1.63 % M
Piece 3	6.48±1.63 % M
Average	6.42±1.63 % M

shows that the average moisture content was 6.42±1.63 which was below the quality standard limit of 10%.

Phase 4: The ash content ranged from 15.055%–18.08%, with an average value of 16.91%, reflecting a relatively high level of mineral accumulation in the product. Although slight variations were observed among samples, this may have resulted from inconsistencies in raw materials or the production process. Overall, the results indicate that crispy Spirogyra algae possesses outstanding nutritional value in terms of both protein and mineral content, while maintaining moisture levels suitable for the development of healthy processed food products.

Table IV: Ash Content of Crispy Algae Analyzed by a Muffle Furnace

Pieces	Ash found in crispy algae (%)
Piece 1	17.59±0.35 %
Piece 2	15.05±0.35 %
Piece 3	18.08±0.35 %
Average	16.91±0.35 %

shows that the average ash content was 16.91±0.35

Conclusions

This study aimed to develop a high-protein crispy snack from Spirogyra and evaluate its nutritional value in comparison with commercially available crispy seaweed products. The study focused on analyzing protein, moisture, and ash contents in order to assess the nutritional potential and overall product quality.

The results revealed that the crispy Spirogyra snack contained 22 g of protein per 100 g, which was nearly twice as high as commercial crispy seaweed products that contained approximately 11.68 g per 100 g. This finding highlights the strong potential of Spirogyra as a highly nutritious plant-based protein source. The higher protein content may be attributed to the natural composition of Spirogyra, a

freshwater algae known for its high protein level, as well as the production process, which did not involve the addition of excessive fat. Consequently, the proportion of protein in the final product was significantly higher than that of conventional snack products.

The crispy Spirogyra snack contained only 2.70 g of fat per 100 g, which was substantially lower than the maximum criterion of 8.00 g per 100 g. This result indicates that the product meets the requirements for a low-fat food and may be considered a healthier snack option for consumers seeking foods with reduced fat content while maintaining high nutritional value.

Regarding physical quality, the moisture content of the developed product ranged from 6.04–6.74%, with an average value of 6.42%, which was below the standard limit of 10%. This indicates that the production process effectively controlled moisture at an appropriate level, contributing to the crisp texture and improved shelf-life potential of the product. Although commercial products exhibited lower average moisture content (1.10%) and greater consistency, this is likely due to the more precise process control available in industrial-scale manufacturing systems.

The ash content showed an average value of 16.91%, which is considered relatively high and reflects the substantial mineral content present in the product. Slight variations among samples may have resulted from inconsistencies in raw materials or uneven heat distribution during processing. Nevertheless, the findings suggest that Spirogyra is a promising source of minerals and can significantly enhance the nutritional value of snack products.

Overall, the study demonstrates that crispy Spirogyra snacks possess outstanding nutritional qualities, particularly in terms of protein and mineral content, while maintaining moisture levels suitable for storage and preservation. These findings are consistent with current trends in healthy food consumption and support the United Nations Sustainable Development Goals (SDGs), particularly SDG 9: Industry, Innovation and Infrastructure, and SDG 12: Responsible Consumption and Production.

Therefore, this project demonstrates the strong potential of Spirogyra as a natural alternative protein source and highlights its potential for further development into commercial food products that address health, economic, and sustainability needs in the future.

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