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Analyzing Edible Algal Species' Nutritious Values using Infrared Hyperspectral Imaging and Machine Learning Techniques

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ABSTRACT

Due to their abundance in nutrients and bioactive chemicals, as well as their application as ingredients in food products, cosmetics, nutraceuticals, fertilizers, biofuels, and other products, algae have become more and more in demand in Western nations in recent years. In order to evaluate the qualitative qualities of algae, their physicochemical and nutritional components must be evaluated in order to determine whether they are suitable for a given end use. Typically, this evaluation is carried out using costly, time-consuming, and destructive traditional chemical analyses that also require sample preparation. The Hyperspectral Imaging (HSI) methodology has shown effective in evaluating and controlling food quality, and it has promise in surmounting the constraints of conventional biochemical methods. This study used conventional methods to examine the nutritional profile (proteins, lipids, and fibers) of seventeen edible macro and microalgae species that are commonly produced worldwide. Furthermore, multi-species models for proteins, lipids, and fibers were created using Artificial Neural Network (ANN) algorithms and a Shortwave Infrared (SWIR) hyperspectral imaging apparatus. A variety of metrics were used to assess the models' predictive power, and all of them shown extremely strong predictive performances for nutritional parameters (for instance, R2=0.9952, 0.9767, and 0.9828 for proteins, lipids, and fibers, respectively). Our findings showed that Shortwave Infrared (SWIR) hyperspectral imaging in conjunction with ANN algorithms can efficiently and sustainably quantify biomolecules in algae species.

Keywords: Sports, Food product, Nutrition benefit

INTRODUCTION

Algae are a diverse range of photosynthetic organisms that can have varying filament complexity, ranging from simple to branched, and differing in size, shape, and color. Because of their strong ability to adapt to a variety of environmental conditions (temperature, light, nutrient content, hydro dynamism, etc.), they are extensively distributed throughout all of the biogeographic areas of the planet. Depending on the type of pigments they contain, algae are categorized as red (*Rhodophyta*), brown (*Phaeophyceae*), green (*Chlorophyta*), or blue-green (*Cyanophyta*). Seaweeds or microalgae are common names for the first three phyla. These are large sea algae that can grow to tens of meters in length. As a matter of fact, there are 8191 green, 2133 brown, and 7533 red species in nature. Microscopic creatures called microalgae can be found in freshwater or marine habitats naturally.

The FAO estimates that 36 million tons (wet weight) of algae were produced in 2021, mostly from marine and aquaculture. With shares of 60%, 25%, 5%, and 4% respectively, China, Indonesia, the Republic of Korea, and the Philippines were the top manufacturers. Seaweeds make up the majority of algae (over 95%), which is taken from the ocean. China, Japan, and the USA were the top importers of algae, while the Republic of Korea, Indonesia, and China were its main exporters. Far Eastern nations (particularly those in Japan, China, Korea, the Philippines, and Indonesia), Mexico, Africa, and to a lesser extent Europe are the regions where algae consumption is highest. However, even in Western nations, their use has significantly expanded recently. But even in Western nations, their use has skyrocketed in recent years.

Based on information acquired on July 10, 2024, from Meticulous Research® (www.meticulousresearch.com/product/algae-market-

5424), the algae market is projected to grow from USD 22.1 billion in 2024 to USD 29.8 billion by 2030.

This encouraging development can be linked to algae's increasing popularity because of their sustainability, advantages for the environment, and nutritional value. Indeed, algae can be utilized to make plastics, fertilizers, biofuels, human meals, cosmetics, nutraceuticals, pharmaceuticals, and gums. They can also be used to extract chemicals and industrial gums (*Phytocolloids* and gelling agents, such agar and carrageenan from Rhodophyta and alginates from *Phaeophyceae*).

Finding new and sustainable food sources is essential because by 2050, there will be up to 9.7 billion people on the planet, and we need to make sure that everyone has access to enough safe, wholesome food. Algae have the potential to contribute significantly to global food security from this angle. Due to the wide range of nutrients that seaweeds and microalgae contain that are vital for human health, there has actually been a growing focus on their use in the creation of functional foods, including pasta, bread, biscuits, snacks, vegetable soups, noodles, stews, burgers, garnishes, chips, candy bars or gums, yogurts, ice creams, drinks etc.

The quality evaluation of algae involves assessing their physicochemical and nutritional components to determine their suitability for specific end uses, which is generally performed using destructive, labor-intensive, expensive, and time-consuming traditional chemical analyses. In recent years, the Hyperspectral Imaging (HSI) technique has been successfully applied in food quality assessment and control. It combines computer vision technology and spectroscopy to identify the sample's two-dimensional images and one-dimensional spectral information. Therefore, each image contains physical properties such as shape, texture, color, and spectral bands, which underline the chemical traits of the food product.

CONCLUSION

Algal genotype, growth and environmental circumstances, and nutrient availability all have a significant impact on the biochemical properties of macro and microalgae, which can result in a wide range of nutritional profiles. The food sector is calling for a quick, simple, and non-destructive evaluation of the qualitative and quantitative properties of algae. Overall, the results showed that the al-gal composition could be accurately predicted by combining machine learning approaches with a SWIR hyperspectral imaging apparatus. Indeed, the artificial neural network-developed multi-species models for proteins, lipids, and fibers demonstrated strong and good predicting abilities. Using the SWIR spectra of seventeen algal species from various evolutionary divisions, one of the study's objectives was to reduce the effects of species-specific factors. As a result, there is a high degree of confidence that the established models may be applied to any species. Furthermore, the sensitivity analysis made it possible to distinguish between the redundant and unnecessary spectral wavelengths and the most informative ones. Even though our results are extremely encouraging, before the models are routinely applied in the food industries, more research on unknown samples is required to determine how excellent they are.