# Development of a Seaweed-based Vegan Burger Patty Rich in Protein

V.S. Danthanarayana[1] and J.W.A.U. Yasas[2]

*[1,2]Department of Food Science and Technology, University of Sri Jayewardenepura, Sri Lanka*

[1]vishwasan1996@gmail.com, [2]umangayasas@gmail.com

## Abstract

*Seaweed is a versatile plant used globally for food and non-food applications, valued for its nutritional and medicinal benefits. In Sri Lanka, seaweed is abundant yet underutilized due to limited awareness. This study developed a vegetarian burger patty incorporating seaweed to address micronutrient deficiencies. Ulva fasciata (green algae) and Sargassum sp. (brown algae) were selected for their high nutrient value. Fresh seaweed was sorted, soaked in a 4% brine solution, rinsed, washed, blanched, dried, ground, and sieved into powder. Steam blanching was selected to preserve seaweed's nutritional and sensory qualities, enhancing the protein and mineral content of burger patties. The proximate composition (dry basis) of Ulva fasciata includes 24.07%±0.02 protein, 0.81%±0.00 fat, 42.14%±0.01 carbohydrates, 11.59%±0.06 ash, 21.37%± 0.02 fiber, whereas Sargassum sp. contains 13.92%±0.03 protein, 0.79%±0.00 fat, 49.89%±0.01 carbohydrates, 26.97%±0.04 ash, 7.98%±0.00 fiber, highlighting significant nutrient content, with Ulva fasciata showing higher protein, fiber values. Burger patties with varying Ulva fasciata content (50%,55%,60%,65%) were prepared with tomato, onion, garlic, corn flour, and spices. Sensory evaluation by a trained panel using a 7-point hedonic scale assessed color, appearance, odor, texture, taste, aftertaste, mouthfeel, and overall acceptability. Proximate analysis of the seaweed-based burger patty revealed a moisture content of 32.45±0.013%, fat content of 10.86±0.042%, protein content of 11.99±0.17%, carbohydrate content of 30.50±0.14%, ash content of 4.79±0.01%, and fibre content of 8.94±0.03%. Elemental analysis showed reduced heavy metals like Pb and As in burger patties compared to raw Ulva fasciata.*

***Keywords: Seaweed, Ulva fasciata, Sargassum sp., Burger patty, Blanching, Vegetarian, Proximate composition***

## I. INTRODUCTION

The global population is projected to reach approximately 9 billion by 2050 and could level off at 10 to 11 billion by the next century (Prager, 2016). This surge necessitates sustainable food alternatives, positioning seaweed-based products as a viable solution due to their nutrient-rich profile and sustainable cultivation, which doesn't require fresh water, chemical fertilizers, or land (Premarathna et al., 2020; Gomez-Zavaglia et al., 2019). Seaweeds, primarily used in Asia, have applications in food, industry, and agriculture (Mahadevan, 2015). In countries like Japan, Korea, and China, seaweed cultivation is a significant industry, whereas in Sri Lanka, it remains underutilized (Wickramasinghe et al., 2020). Seaweeds, classified as algae, are categorized into brown (phaeophyta), red (rhodophyta), green (chlorophyta), and blue-green (cyanophyta) (Emrkb and Rmsm, 2015). They are recognized for their high levels of protein, carbohydrates, minerals, vitamins, and trace elements like iodine (Jayakody et al., 2019). Historically, seaweed has been a part of diets in Japan since the fourth century and in China since the sixth century, used for its nutritional and medicinal properties (Baweja et al., 2016). Currently, China, Japan, and Korea are the largest consumers, but global demand is increasing, prompting the development of cultivation industries that now meet over 90% of market needs (Quitral et al., 2021; Puminat, 2019).

In Sri Lanka, the need for more awareness about seaweed's benefits has hindered its utilization. This study focuses on developing a high-protein, non-meat seaweed burger patty to cater to the growing demand for vegan products, particularly in Western countries and among populations reducing meat consumption (Premarathna et al., 2019). The research examines the nutritional and sensory properties of seaweed-based patties, emphasizing their potential to provide a balanced diet with high protein and fibre content, thus addressing the nutritional deficiencies of conventional burger patties.

## II. LITERATURE REVIEW

### 2.1 Seaweed as a Nutritional and Functional Food Source

Seaweed, a marine macroalgae, has been utilized for centuries in various cultures for its nutritional and medicinal benefits. Seaweeds are rich in essential nutrients, including proteins, vitamins, minerals, dietary fibres, and bioactive compounds, which confer multiple health benefits. The nutritional profile of seaweeds varies significantly across species, making them a valuable addition to the human diet (Dhargalkar & Pereira, 2005).

#### 2.1.1 Nutritional Benefits

Seaweeds are a potent source of essential micronutrients such as iodine, iron, calcium, magnesium, and vitamins A, B, C, and E. Iodine, in particular, is crucial for thyroid function and is abundant in seaweeds like kelp. The protein content in seaweeds, though varying among species, provides essential amino acids, making it a beneficial supplement for vegetarian and vegan diets (MacArtain et al., 2007). The high fibre content in seaweed aids in digestive health and contributes to a feeling of fullness, which can help in weight management (Jiménez-Escrig & Sánchez-Muniz, 2000).

#### 2.1.2 Medicinal Properties

Seaweeds possess various bioactive compounds, including polysaccharides, polyphenols, and carotenoids, which exhibit antioxidant, anti-inflammatory, antiviral, and anticancer properties. These compounds can help reduce the risk of chronic diseases such as cardiovascular diseases, diabetes, and cancer (Gupta & Abu-Ghannam, 2011). The polysaccharides in seaweed, such as alginate, carrageenan, and agar, have been shown to enhance immune function and promote gut health by acting as prebiotics (Zaporozhets et al., 2014).

#### 2.1.3 Seaweed in Food Products

The incorporation of seaweed into food products has gained traction due to its health benefits and functional properties. Seaweeds are used as gelling, thickening, and stabilizing agents in various food formulations. Their unique umami flavour also enhances the taste profile of many dishes. Recent studies have explored the use of seaweed in bakery products, snacks, beverages, and meat alternatives (Sappati et al., 2019).

#### 2.1.4 Seaweed in Meat Alternatives

The rising demand for plant-based meat alternatives has led to the exploration of seaweed as a key ingredient due to its high nutrient density and functional properties. Seaweed-based meat analogues have been developed to mimic the texture and flavour of conventional meat products while providing added health benefits. The addition of seaweed can enhance the nutritional profile of these products, offering a rich source of vitamins, minerals, and antioxidants (Mouritsen et al., 2019).

### 2.2 Challenges and Opportunities

Despite its benefits, seaweed still needs to be utilized in many parts of the world due to limited consumer awareness and acceptance. The unique taste and texture of seaweed can be a barrier to its incorporation into mainstream diets. However, with increasing interest in sustainable and health-promoting foods, there is significant potential for the growth of seaweed-based products. Research and development efforts are focused on improving the sensory qualities of seaweed products and educating consumers about their benefits (Fleurence, 2016).

### 2.3 Seaweed in Sri Lanka

Sri Lanka has a rich diversity of seaweed species, particularly along its coastline. The potential for utilizing these resources to address nutritional deficiencies and promote health is significant. Local seaweed species, such as Ulva fasciata and Sargassum sp., are abundant and can be sustainably harvested year-round. Developing value-added seaweed products, such as the vegan seaweed burger patty, can help promote the consumption of seaweed and improve public health outcomes in Sri Lanka (Mendis & Kim, 2011).

## III. MATERIALS AND METHODS

### 3.1 Sample Collection

Seaweed Ulva fasciata and Sargassum sp. were collected from the southern coast of Sri Lanka, specifically Thalpawatta Thalangama Matara. Samples were washed, rinsed with seawater, and stored in plastic bags. Upon arrival at the laboratory, they were further washed with distilled water, frozen, and dried at 60°C for 8 hours before being ground and stored at 4°C.

### *3.2 Processing of Seaweeds*

The fresh, undamaged seaweeds were sorted and soaked in a 4% brine solution before being rinsed. Blanching methods, including hot water and steam blanching, were compared through sensory evaluation of appearance, odour, taste, and overall acceptability by a trained panel.

### *3.3 Chroma meter Values*

Measured L*, a*, b* color values using a Lovibond LC 100 chroma meter (n=15).

### *3.4 Development of Burger Patty with Ulva Fasciata*

Ingredients: Seaweeds, corn starch, carrot, tomato, spice mix powder, olive oil, onion, and salt.
Method: Ingredients were mixed, cooked, and deep-fried. The sensory evaluation identified the best formula.

### *3.5 Proximate Analysis of Fresh Seaweeds*

The analyses followed AOAC (2012) and SLS 824 (2018): moisture content was determined using the oven drying method and rapid moisture analyzer; ash content with a muffle furnace; crude fat via a Soxtherm apparatus; crude fibre with a Fibertc hot extractor; protein by the Kjeldahl method using a UDK139 distillation unit; and carbohydrate content calculated by difference (Igbabul et al., 2014).

### *3.5 Proximate Composition Analysis of Burger Patty*

Table 01 : Methods used for Proximate Composition Analysis of Burger Patty

| Component | Method |
|---|---|
| Moisture Content | Oven Drying Method and Rapid Moisture Analyzer |
| Protein Content | Kjeldahl Method with UDK139 Distillation Unit |
| Fat Content | AOAC (2012) official method |
| Fiber Content | AOAC (2012) official method |
| Ash Content | AOAC (2012) official method |
| Carbohydrate Content | method described in literature Igbabul B et al., 2014 |

### *3.6 Sensory Evaluation*

Appearance, colour, odour, texture, and overall acceptability were assessed using a seven-point hedonic scale. The results were analyzed using the Kruskal-Wallis Test in MINITAB.

### *3.7 Determination of Heavy Metal Content*

The analysis was performed using ICP-MS following the protocols outlined in AOAC 2015.01, AOAC 2011.4, and AOAC 99.10.

### *3.8 Analysis of Shelf Life*

Microbiological studies were conducted according to SLS 1463:2013 (ISO 7218:2007). Yeast and mould counts were performed per SLS 516 PART 2/SECTION 1:2013 (ISO 21527-1:2008), and the total plate count was conducted as per SLS 516 PART 1/SECTION 1:2013 (ISO 4833-1:2013).

## IV. RESULTS AND DISCUSSION

Figure 02 - Fresh seaweeds (*Ulva fasciata*)

Figure 03 - Fresh seaweeds (*Sargassum* sp.)

Figure 04 - Dried seaweed samples

### *4.1 Selecting the best pretreatment method*

Steam blanching was selected based on physical conditions and organoleptic properties, over hot water blanching despite taking more time, as it better preserves the texture, color, and nutrients of seaweed. As a pre-treatment, blanching not only enhances shelf life but also helps remove fishy odors, improving overall product quality. A sensory evaluation was conducted by assessing key attributes such as appearance, odor, taste intensity, and overall acceptability using a seven-point hedonic scale, with participation from aseven-member trained industrial panel.

### *4.2 Proximate Analysis*

The proximate composition of *Ulva fasciata* and *Sargassum* sp. was analyzed, revealing significant differences in moisture, protein, fat, carbohydrate, ash, and fibre content.

Table 02 : Results of proximate composition of dry powdered *Ulva fasciata* and *Sargassum* sp.

| Composition Dry Basis (%) | *Ulva fasciata* | *Sargassum* sp. |
|---|---|---|
| Moisture | 85.72±0.00 | 84.82±0.00 |
| Protein | 24.07±0.02 | 13.92±0.03 |
| Fat | 0.81±0.00 | 0.79±0.00 |
| Carbohydrate | 42.14±0.01 | 49.89±0.01 |
| Ash | 11.59±0.06 | 26.97±0.04 |
| Fibre | 21.37±0.02 | 7.98±0.00 |

### *4.3 Proximate Composition Analysis of Seaweed-Based Burger Patty*

Table 03: Proximate Composition of Seaweed-Based Burger Patty

| Composition /Dry Basis (%) | Percentage ± SD |
|---|---|
| Moisture | 32.45±0.013 |
| Protein | 11.99±0.17 |
| Fat | 10.86±0.04 |
| Carbohydrate | 30.50±0.14 |
| Ash | 4.79±0.01 |
| Fibre | 8.94±0.03 |

### *4.4 Sensory Evaluation of the Burger Patty*

The sensory evaluation assessed consumer preference across four burger formulations with varying seaweed content. Kruskal-Wallis Test showed significant differences in attributes like appearance, colour, odour, texture, and overall acceptance. The most preferred sample contained 55% seaweed, 18% corn starch, 15% carrot, 10% tomato, 2% spice mix, 0.5% olive oil, and 0.5% salt.

### *4.5. Determination of Heavy Metal Content*

Heavy metal content in raw materials and the final product was within permissible limits, ensuring safety

Table 04 : Heavy Metal Content in Seaweed and Final Product

| Element (ppm) | Powder Product | Final Product | Permissible Value |
|---|---|---|---|
| Pb | 0.08 | 0.08 | 6.0 |
| Cd | 0.092 | <0.05 | 0.2 |
| As | 1.21 | 0.15 | 1.4 |
| Hg | <0.05 | <0.05 | 0.5 |

The low levels of heavy metals confirm the relative safety of the macro-algae from the southern coast of Sri Lanka, supporting their use in food products.

## V. CONCLUSION

This study successfully demonstrated the nutritional potential of incorporating *Ulva fasciata* and *Sargassum* sp. into vegetarian burger patties. Both seaweed varieties were found to be rich in essential nutrients such as protein, minerals, and carbohydrates, while being low in fat. Notably, the high fiber content in these seaweeds contributes to various health benefits. The results indicated that *Ulva fasciata* is particularly suitable for developing burger patties, offering a high-protein and fiber-rich alternative for vegetarian diets. The processed seaweed patties showed enhanced nutritional profiles, making them a valuable addition to the food industry, especially in addressing nutritional deficiencies. This study found that steam blanching, compared to hot water blanching, is the superior method for preserving the nutritional content and sensory properties of seaweed-based products. Additionally, the reduction in heavy metal content through processing further supports the safety and efficacy of using seaweed as a food ingredient. The findings of this study highlight the potential for seaweed-based products to contribute to sustainable and health-promoting food options, aligning with the growing demand for plant-based alternatives. This study revealed that *Ulva fasciata* (green algae) and *Sargassum* sp. (brown algae) are nutritionally rich in protein, minerals, and carbohydrates, while being low in fat. Both varieties contain high amounts of fiber, which, though indigestible by human enzymes, offers several health benefits. The essential and trace element content, as well as heavy metal levels in seaweed, vary depending on species and location, and are altered by processing steps in product development. *Ulva fasciata* has been successfully used to develop a fiber-rich vegetarian burger patty, which can be commercialized. Given the increasing global acceptance of seaweed as a vital nutrient source, it may address deficiencies in protein, carbohydrates, and minerals. The findings of this study conclude that seaweeds are a potential health food and can serve as valuable ingredients in the food industry due to their high nutritional and commercial value. Enhancing product quality and expanding the range of seaweed-based products will further boost their appeal.

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