Biochemical Composition and Nutritional Potential of Ulva-lactuca Algae as a Sustainable Marine Resource which available along Saurashtra coast of Gujarat In India

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Abstract

Marine macroalgae have emerged as promising sustainable resources for nutritional and functional applications. Green seaweeds of the genus Ulva have attracted special interest owing to their biochemical diversity and ecological adaptability, making them a potential sustainable resource for nutritional and functional uses among marine macroalgae. This research looks at the nutritional value and biochemical make-up of Ulva species, using amino acid profiling to determine how good the protein is. This marine biomass has nutritional value because quantitative analysis showed that it contains both essential and non-essential amino acids in significant amounts. With an average concentration of 295.68 mg/kg (0.30 g/kg; 0.03%), arginine was determined to be the most abundant essential amino acid. Isoleucine and leucine followed at 291.01 and 220.44 mg/kg, respectively. While sulfur-containing amino acids like cystine (18.44 mg/kg) and methionine (28.67 mg/kg) were relatively low, valine was also present at significant levels (184.94 mg/kg). At 1.15 g/kg, or about 0.11 percent of the total biomass, the total amount of essential amino acids was calculated. These results suggest that Ulva has a moderately valuable amino acid profile, which could make it a viable alternative protein source for sustainable diets, nutraceuticals, and functional foods. The Ulva lactuca were collected from the Saurashtra coast of Gujarat In India. The study highlights the significance of marine algae in meeting the world's nutritional needs and promoting sustainable resources which available along Saurashtra coast of Gujarat In India.

Introduction

India has a coastline of more than 8,000 kms and harbours about 844 species of seaweeds, commercial cultivation is yet to take place in India. R&D efforts over the years have resulted in valuable information regarding biodiversity, ecological conditions suitable for farming, species that could be incorporated in the cultivation, etc. India is rich in algal biodiversity, has large stretches of suitable areas for cultivation and has communities of traditional fisherfolk. However, Indian seaweed industry suffers from absence of commercial cultivation practices, lack of infrastructure for commercial cultivation and absence of policy support. Since, seaweed is not an important aspect of Indian diet, its cultivation remains a low-priority area. The Saurashtra coast is part of the larger Gujarat coast, which has a rich seaweed diversity of over 200 species, of which *Ulva* is a dominant. *Ulva lactuca* (sea lettuce) is widely distributed along the Saurashtra region of Gujarat, India.The presence of mineral rich seaweed Ulva shows that the coast is rich in diversity of economically important species. [15}.

Ulva (species) has been regarded as a popular and nutritious dietary option in various parts of the world. It is a popular culinary ingredient in Indo-Pacific countries due to its widespread availability and high nutritional value [1]. The growing global demand for sustainable and nutritionally dense food resources has sparked renewed interest in marine macroalgae as alternative sources of essential nutrients. Green seaweeds of the genus Ulva (Chlorophyta), also known as sea lettuce, have received a lot of attention because of their rapid growth, widespread geographical distribution, and high biomass productivity [2, 3]. Ulva species are abundant in coastal ecosystems around the world and have long been consumed in Asian and coastal communities, demonstrating their potential as functional food ingredients. Ulva algae have a favourable macronutrient composition, including proteins, dietary carbohydrates, and low lipid content, as well as a wide range of micronutrients such as vitamins, minerals, and trace elements. Ulva spp. are also high in bioactive compounds, such as sulphated polysaccharides, phenolic compounds, pigments, and antioxidants, which have been linked to a variety of health benefits, including anti-inflammatory, antimicrobial, and antioxidant activity. These characteristics make Ulva a promising candidate for use in the food, nutraceutical, and feed industries [4, 5].

Despite increased interest in Ulva algae, the nutritional and biochemical composition of these seaweeds varies greatly depending on species, environmental conditions, seasonal variations, and geographical location. Such variability necessitates region-specific nutritional profiling in order to accurately assess dietary value and potential industrial applications. A thorough examination of proximate composition and biochemical constituents is therefore required to validate Ulva as a sustainable nutritional resource [6, 7].

In this context, the current study seeks to systematically investigate the nutritional profile of Ulva algae by examining its proximate composition and key biochemical constituents. The findings of this study are expected to provide valuable insights into Ulva algae's nutritional potential and support its use as an environmentally friendly and functional marine-derived food resource. Ulva is one of the main green algae that cause green tide disasters. Ulvan is the primary component polysaccharide of Ulva's cell wall, and its complex structure and monosaccharide composition resulted in a variety of biological functions. However, the high value and effective use of extracted ulvan have been hampered by a variety of limitations, including high molecular weight, low solubility, and poor bioavailability [8, 9].

Materials and Methods

The current study's methodology was designed to systematically assess the nutritional and biochemical composition of Ulva algae. Analyses were carried out using standardised and reproducible methods to ensure nutritional profiling reliability and to allow for comparison with previously reported studies.

1. **Proximate composition analysis**

Moisture content was determined by oven-drying a known weight of algal powder at 105 °C until a constant weight was obtained. The dried sample was incinerated in a muffle furnace at 550 °C for 4-6 hours to determine its ash content, which was then expressed as a percentage of dry weight. Crude protein content was calculated using the Kjeldahl method, which involved determining total nitrogen and applying a conversion factor of 6.25 [10, 11]. The crude lipid content was determined using Soxhlet extraction with petroleum ether as the solvent. The defatted sample was digested sequentially with acid and alkali to determine crude fibre. The total carbohydrate content was calculated by subtracting the sum of moisture, ash, protein, lipid, and fibre from 100%.

2. **Mineral Profiling**

It was achieved using Induced Coupled Plasma Mass Spectroscopy and following the prescribed protocol. To a pre-cleaned digestion tube, we added 30 mL of a 0.1 N hydrochloric acid (HCl) solution after precisely weighing 5 g of Ulva. To guarantee full extraction of the target components, the mixture was acid-digested using a programmed digestion system for 1 hour. The digestion process was stopped when the digest had cooled to room temperature. Before further analysis, the final volume was adjusted by diluting it with 0.1 N HCl.

3. **Vitamin profiling**

Using LC/MS-MS technique, the vitamin profiling was achieved. A 2 g Ulva sample was precisely weighed and transferred to a pre-cleaned centrifuge tube, followed by the addition of 10 mL of distilled water. Next, add 75 µL of ammonia solution to the mixture and mix thoroughly. The suspension was centrifuged at 10,000 rpm for 20 minutes at 4 °C to aid in phase separation. Following centrifugation, the supernatant was carefully transferred to a fresh centrifuge tube and cleaned up with n-hexane. The mixture was vortexed for 2 minutes to ensure efficient extraction, then the n-hexane layer was removed and discarded. Following the clean-up procedure, the aqueous phase was appropriately diluted with the mobile phase before proceeding to chromatographic analysis.

4. **Amino Acid profiling**

After precisely measuring and adding 0.5 g of Ulva to a 100 mL volumetric flask, a diluent of water and methanol (1:1, v/v) was added, followed by 50 mL of the mixture. To help with phase separation, the mixture was moved to a 50 mL centrifuge tube and spun at 4,000 rpm. We then sonicated the suspension for 15 minutes to increase the efficiency of the extraction process, and we used the same diluent to adjust the final volume. Before the liquid chromatography-mass spectrometry (LC-MS) analysis, the supernatant was meticulously collected and passed through a 0.45 µm nylon syringe filter.

Results

1. **Proximate composition analysis**

The result for the proximate composition is given below in table 1. The proximate composition analysis of Ulva lactuca showed a high moisture content (83.26 ± 1.21%), indicating its fresh and hydrated nature, typical of marine macroalgae. Ulva's moderate protein content (6.90 ± 0.24%) supports its nutritional relevance as a supplementary protein source. The low lipid content (0.77 ± 0.03%) aligns with green seaweeds' low-fat profile, making it suitable for low-fat diets. Ulva lactuca has a high ash content (20.19 ± 1.18%), indicating mineral accumulation and potential as a valuable source of essential minerals. The majority of dry matter (71.62 ± 1.32%) was composed of carbohydrates, with polysaccharides contributing to nutritional value and functional properties. The results show that Ulva lactuca has a high carbohydrate and mineral content and low lipid levels, making it suitable for functional foods and nutraceuticals.

Table 1: Composition of Ulva species

Species	Moisture	Protein	Fat	Ash	Carbohydrate
Ulva lactuca	83.26 ± 1.21	6.90±0.24	0.77±0.032	20.19 ± 1.18	71. 1.32

2. **Mineral profiling:**

Analysis of Ulva lactuca's mineral composition revealed significant amounts of important macro- and trace elements. The presence of calcium, the most abundant mineral at 6.32 percent, suggests that Ulva lactuca may be an excellent food supplement for maintaining healthy bones and metabolic processes. Because of its importance in enzyme reactions and energy metabolism, magnesium's high concentration (3.76%) is also noteworthy. Along with these macrominerals, trace elements like cobalt (0.38%) and copper (0.55%) were also found in detectable amounts. The minerals concentration is summarized in Table-2.

Table 2: The below table is showing the Minerals Concentration in percentages:

Species	Ca%	Co%	Cu%	Mg%
Ulva lactuca	6.32%	0.38%	0.55%	3.76%

3. **Vitamin profiling:**

Vitamin profiling in Ulva lactuca was carried out using a validated analytical method, and the quantification was performed through calibration curves prepared for each vitamin standard.The calibration curves for water-soluble vitamins were established over a concentration range of 5 ppb to 500 ppb. All analytes showed good linearity with acceptable correlation coefficients (R^2), indicating the reliability of the analytical method for quantification of vitamins in the sample. The calibration curve are showing in Fig-1.The quantified vitamin content of the sample is presented in mg/100 g. Among the analyzed vitamins, Pantothenic acid (B5) was found in the highest concentration (1.375 mg/100 g), followed by Riboflavin (B2) (0.429 mg/100 g) and Nicotinamide (B3) (0.310 mg/100 g). Thiamine (B1) was present in moderate amounts (0.040 mg/100 g), while Pyridoxine (B6), Folic acid (B9), and Cyanocobalamin (B12) were detected in lower concentrations. These results, which are mentioned in Table-3, indicate that the Ulva lactuca has a valuable source of essential B-complex vitamins.

Table 3: The below table is showing the Vitamins Conc.in mg/100gm

Thiamine_B1	Riboflavin_B2	:Nicotinamide_B3	Pantothenic Acid_B5	Pyradoxin_B6	Folic Acid_B9	Cynocobalmine_B12
0.040	0.429	0.310	1.375	0.007	0.019	0.017

4. **Amino Acid profiling**

Ulva seaweed contains good amounts of essential and non-essential amino acids, indicating its nutritional value . With an average concentration of 295.68 mg/kg (0.30 g/kg; 0.03%), arginine was the most abundant essential amino acid, followed by isoleucine (291.01 mg/kg) and leucine (220.44 mg/kg). Methionine (28.67 mg/kg) and cystine (18.44 mg/kg) were less abundant than valine (184.94 mg/kg). Essential amino acids made up 1.15 g/kg, or 0.11% of the total composition, indicating a moderate but nutritionally valuable profile. There were more non-essential amino acids than essential ones. Tyrosine was the most abundant non-essential amino acid, at 1041.29 mg/kg (1.04 g/kg; 0.10%), followed by glutamic acid (359.23 mg/kg) and alanine (235.12 mg/kg). Due to marine macroalgae's high acidic amino acid content, aspartic acid contributed 287.49 mg/kg. Glycine, proline, serine, and alanine weren't essential but moderately present. It contained 2.16 g/kg of non-essential amino acids, or 0.22% of the total composition. The amino acid profiling of different replicated samples of Ulva lactuca is presented in Fig. 2.The percentage occurrence of different amino acids is presented in Table-4.

Table 4: Percentage Occurrence of different amino acids in Ulva algae.

Compound Name	Ulva Seaweeds Sample_01(mg/kg)	Ulva Seaweeds Sample_02(mg/kg)	Ulva Seaweeds Sample_03(mg/kg)	Ulva Seaweeds Sample_04(mg/kg)	Average(mg/kg)	Average(gm/kg)	Re Pe
Arginine	334.65	288.53	281.27	278.25	295.68	0.30	0.(
Cystine	19.89	18.44	17.65	17.78	18.44	0.02	0.(
Isoleucine	352.42	397.17	215.99	198.45	291.01	0.29	0.(
Leucine	268.01	289.92	158.99	164.84	220.44	0.22	0.(
Methionine	28.31	28.07	28.85	29.44	28.67	0.03	0.(
Phenylalanine	70.31	77.80	60.30	54.78	65.80	0.07	0.(
Threonine	44.18	44.19	43.58	42.16	43.53	0.04	0.(
Valine	154.88	182.78	194.15	207.97	184.94	0.18	0.(
Total Essential Amino Acid						1.15	0.'
Alanine	233.48	233.44	237.97	235.57	235.12	0.24	0.(
Glutamic Acid	354.19	368.20	357.78	356.76	359.23	0.36	0.(
Glycine	95.51	87.99	101.99	92.39	94.47	0.09	0.(
Aspartic Acid	289.46	290.50	282.32	287.66	287.49	0.29	0.(
Proline	92.62	81.93	68.03	67.17	77.44	0.08	0.(
Serine	63.90	65.40	62.11	60.30	62.93	0.06	0.(
Tyrosine	954.91	1033.76	1080.34	1096.14	1041.29	1.04	0.'
Total Non Essential Amino Acid						2.16	0.2

Discussion and Conclusion

Ulva, belonging to the Ulvaceae family and is known for its abundance of biochemical compounds and adaptability. The wide range of biological characteristics and possible medical uses of Ulva have made it a popular topic in recent years [11, 12]. In addition to its many beneficial effects, such as antimicrobial, antioxidant, and anti-inflammatory properties, it is well-known for its diverse bioactive compounds and rich nutritional profile. This review will give you the rundown on Ulva, including its location, chemistry, and all the different ways it can be used [. Part one of the paper offers background information on seaweeds in general and Ulva in particular, including its taxonomy, worldwide distribution, seasonal distribution, nutritional value (particularly its amino acid contents), and bioactive chemicals. Part two delves into scientific details. The second part of the article delves into the many applications of the Ulva, particularly in the fields of medicine and pharmaceuticals, cosmetics, and industry [13, 14].

The mineral composition analysis of Ulva lactuca showed significant macro- and trace element levels. Calcium was the most abundant mineral, accounting for 6.32%, suggesting Ulva lactuca could be a good source of calcium for bone health and metabolism. Due to its role in enzymatic reactions and energy metabolism, magnesium was also high (3.76%). These macrominerals were found alongside trace elements like copper (0.55%) and cobalt (0.38%). Copper is a vital cofactor for antioxidant and metabolic enzymes, while cobalt, a vitamin B_{12} component, is vital for erythropoiesis and cellular metabolism. Ulva lactuca's presence of macro- and micronutrients makes it a promising mineral-rich ingredient in functional foods, nutraceuticals, and animal feed.

Ulva seaweed has nutritional value because it contains both essential and non-essential amino acids in significant amounts, according to amino acid profiling. With an average concentration of 295.68 mg/kg (0.30 g/kg; 0.03%), arginine was the most abundant of the essential amino acids. Isoleucine and leucine followed at 291.01 and 220.44 mg/kg, respectively. While cystine (18.44 mg/kg) and methionine (28.67 mg/kg) were relatively low levels, valine was also present in significant amounts (184.94 mg/kg). There was a moderate but nutritionally valuable essential amino acid profile, with a total of 1.15 g/kg of amino acids accounting for 0.11% of the total composition.

There were greater amounts of non-essential amino acids than of essential ones. Following alanine (235.12 mg/kg), glutamic acid (359.23 mg/kg), and tyrosine (1041.29 mg/kg; 1.04 g/kg; 0.10%), the non-essential amino acids were in order of dominance. In keeping with the usual abundance of acidic amino acids in marine macroalgae, aspartic acid also made a substantial contribution (287.49 mg/kg). There were moderate amounts of other non-essential amino acids like alanine, proline, serine, and glycine. At 2.16 g/kg, or 0.22% of the total composition, non-essential amino acids were recorded. Arginine, tyrosine, glutamic acid, and branched-chain amino acids like leucine, isoleucine, and valine are abundant in Ulva seaweed, although the overall composition of the amino acids suggests that non-essential amino acids predominate over essential ones. The well-rounded amino acid profile of Ulva lends credence to its prospective use as a functional ingredient in nutraceutical formulations, animal feed, and human nutrition, specifically as an additional source of protein.

Declarations

Ethics Approval & Consent:

Not Applicable

Clinical trial number:

Not applicable.

Consent for publication:

Not Applicable

Availability of data and materials:

All data supporting the findings of this study are available within the paper and its Supplementary Information and related files.

Funding Declaration:

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Authors' contributions:

Dr.Ashish Jha conceptualized and designed the study. Mr. Manish Singh and Mr. Parshant Vadaliya analysed and interpreted the data. Mr.Manish Singh and Mr.Vadaliya draft the manuscript.Dr.Gireesh Babu K and Dr.Ashish Jha has reviewed the manuscript . All authors read and approved the final Manuscript.

Conflicts of Interest:

The authors declare no conflicts of interest.

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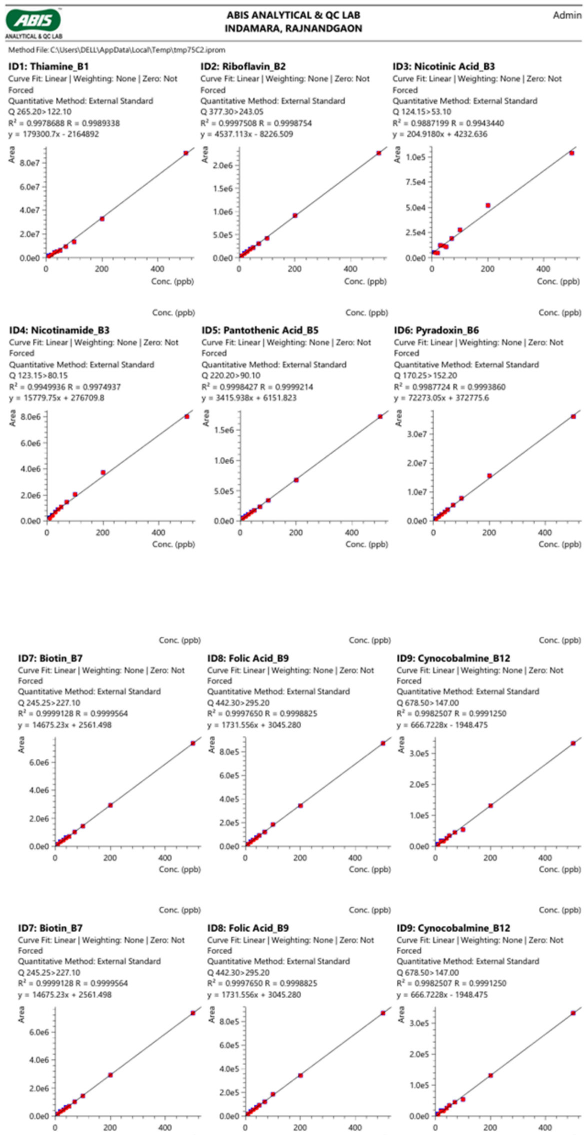
Figures



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Date Acquired: 10/21/2023 1:14:05 AM
Acquired by: System Administrator
Method File: D:\Water Soluble Vitamins_LCMSMS\LCMSMS\Aq Method\05102023_WSV.lcm
Data File: WSV_SampleWSVCheck_01_30
Vial: 22 | Inj. Volume: 5.0000uL | Tray: 1

Name	Found RT	Area	Ref 1 Actual Ratio	Conc.	Dil. Factor
Thiamine_B1	1.458	200983	14.83	395.8505	30.00000
Riboflavin_B2	9.233	640285	42.92	4288.0430	30.00000
Nicotinic Acid_B3	----	----	0.00	----	30.00000
Nicotinamide_B3	6.038	1905042	39.04	3095.7383	30.00000
Pantothenic Acid_B5	7.512	1572070	24.17	13752.4626	30.00000
Pyradoxin_B6	5.165	534302	112.73	67.0485	30.00000
Biotin_B7	----	----	0.00	----	30.00000
Folic Acid_B9	8.484	13826	49.76	186.7817	30.00000
Cynocobalmine_B12	8.257	1850	11.15	170.9339	30.00000

Figure 1

showing the calibration graph range from 5 ppb to 500 ppb conc and Sample concentaion in mcg/kg under calibration curve standards.

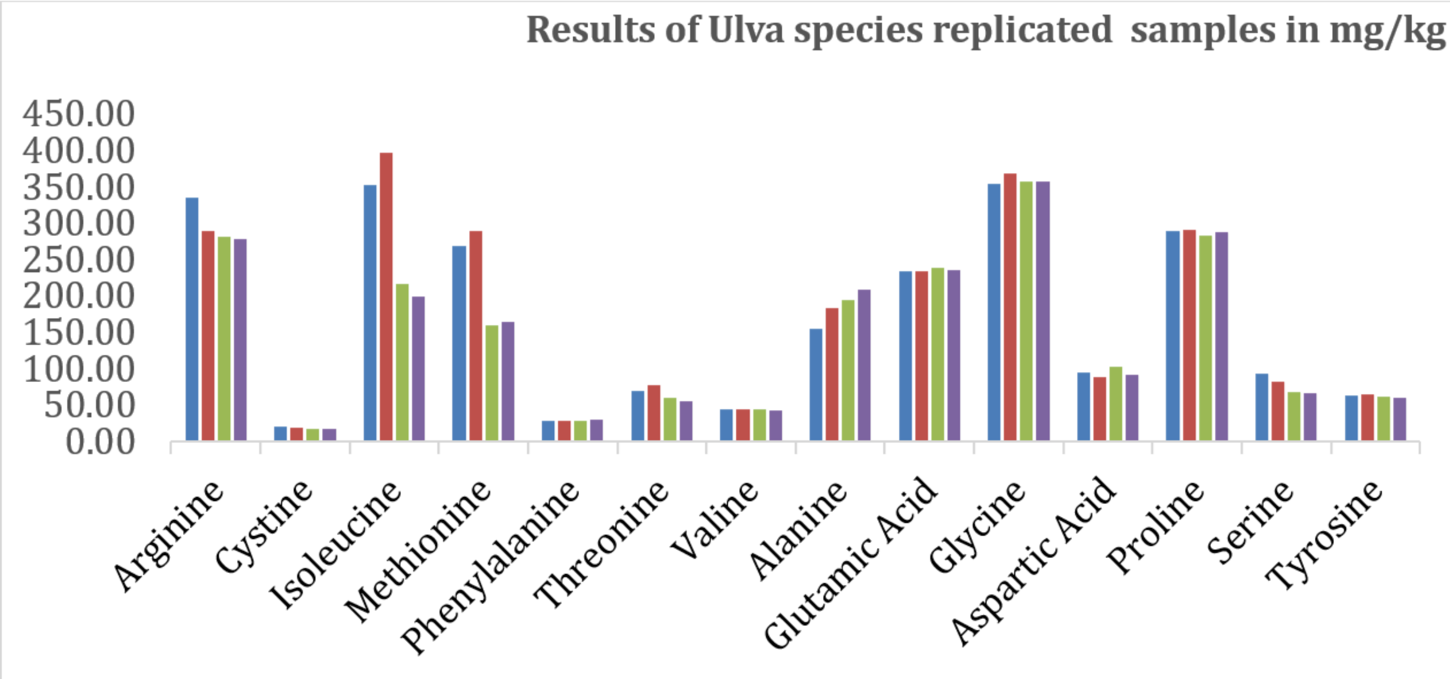

Figure 2

Amino acid profiling of different replicated samples of Ulva lactuca

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- VitaminsAminoAcidsMineralsresults.zip