JURNAL ILMIAH MEDICAMENTO

Vol.12 No.2 (September 2026)
page 322-330
https://doi.org/10.36733/medicamento.v12i2.13145
e-ISSN: 2356-4814

Original Article

Combination of *Ulva lactuca* and *Moringa oleifera* Extracts as Additives in Salt Production and Evaluation of Their Activities

Ikha Rahardiantini*, Lili Sartika, Masyitah Novia Yanti

Diploma III Study Program in Pharmacy, STIKES Hang Tuah Tanjungpinang, Jl. W.R. Soepratman, Tanjungpinang 29125, Riau Islands, Indonesia

Submitted : 04-12-2025
Revised : 21-09-2025
Accepted : 30-09-2025

Keywords: CUPRAC, DPPH, *Moringa oleifera*, Salt, *Ulva Lactuca.*

Correspondence:
Ikha Rahardiantini
ikhaafridho@gmail.com

License: *CC BY-NC-SA 4.0*

Copyright ©2026 Authors

Abstract

Background: Hypertension is a major cause of mortality in Indonesia. *Ulva lactuca* can be utilized as a raw material for low-sodium, potassium-rich salt production, while *Moringa oleifera* may further enhance potassium content.
Objective: To determine the chemical composition and antioxidant activity of *Ulva lactuca* and *Moringa oleifera* extracts.
Methods: Proximate composition, extraction yield, mineral and heavy metal contents, phytochemical constituents, DPPH radical-scavenging activity, and CUPRAC antioxidant capacity were evaluated.
Results: In *Ulva lactuca*, ash was the major component (40.08%) and protein the lowest (11.73%), whereas in *Moringa oleifera*, moisture was highest (25.43%) and carbohydrate lowest (6.94%). *Ulva lactuca* contained 109.65 mg/g sodium and 124.24 mg/g potassium, while *Moringa oleifera* contained 0.79 mg/g sodium and 5.28 mg/g potassium. The Na:K ratios were 0.88 and 0.15, respectively. Both extracts exhibited very strong antioxidant activity, with IC_{50} values of 11.265 µg/ml (*Ulva lactuca*) and 6.828 µg/ml (*Moringa oleifera*). Phytochemical screening revealed alkaloids, flavonoids, phenols, and tannins in both extracts. The antioxidant capacities of *Ulva lactuca* and *Moringa oleifera* extracts were 55.849 ± 5.59 and 0.013 ± 2.35 µmol ascorbic acid equivalent/g extract, respectively.
Conclusion: *Ulva lactuca* and *Moringa oleifera* are suitable alternative raw materials for salt production due to their favorable Na:K ratios and strong antioxidant activity. These characteristics support their potential development as functional low-sodium, potassium-enriched salt products that may contribute to healthier dietary strategies for hypertension prevention and management.

How to Cite: (*citation style* AMA 11th Ed.)
Rahardiantini I, Sartika L, Yanti MN. Combination of *Ulva lactuca* and *Moringa oleifera* Extracts as Additives in Salt Production and Evaluation of Their Activities. *J. Ilm. Medicam.* 2026;12(2):322-330. doi: 10.36733/medicamento.v12i2.13145

INTRODUCTION

As the world's largest archipelagic nation, Indonesia possesses abundant marine resources, including marine plants like seaweed, which hold immense potential to address national public health challenges. Hypertension has become a major health issue in Indonesia, closely linked to traditional dietary patterns that rely heavily on high-sodium seasonings and salt-preserved foods. While national health strategies strongly advocate for a reduction in daily salt consumption to manage cardiovascular risks, altering ingrained dietary habits remains difficult. Therefore, developing alternative seasonings from local marine resources offers a strategic, culturally appropriate solution to lower sodium intake without sacrificing taste. Coastal communities in Indonesia use seaweed more as food. Seaweed management then expanded widely in the fields of cosmetics and medicine. The innovative use of seaweed that has been carried out in the food sector is that it is used as a raw material in making low-sodium salt.[1]

Research has been carried out on the use of seaweed, especially green seaweed (*Ulva lactuca*) as a raw material for making seaweed salt.[2] Results from previous research by heating different seaweed salts produce quite high levels of sodium and potassium with a ratio of 2.95-3.88.[2] The ideal need for minerals, especially sodium and potassium in fulfilling a salt diet for hypertension, is close to 1.[3]To reduce the high sodium and potassium mineral ratio of seaweed salt, the addition of other raw materials can be used. Additional raw materials that can be used in making seaweed salt are Moringa leaves (*Moringa oleifera*).[4]

Moringa (*Moringa oleifera*) leaves contain β-carotene, protein, vitamin C, calcium and potassium, and are a good food source as a natural antioxidant, because of the presence of various types of antioxidant compounds such as

ascorbic acid, flavonoids, phenolics and carotenoids, which can prevent water retention, regulate cholesterol levels and maintain blood sugar levels.[5] In Asia, Moringa leaves are also known for their use to increase breast milk production and are sometimes prescribed for anemia.[6] Moringa leaves (*Moringa oleifera*) are thought to have a role in reducing the high sodium and potassium ratio in seaweed salt.[7]

Previous studies on the utilization of green seaweed *Ulva lactuca* as a raw material for functional salt have primarily been conducted using samples collected from the waters of Sekotong, West Nusa Tenggara.[6] However, information regarding *Ulva lactuca* from Bintan waters, Riau Islands, remains unavailable, although environmental conditions may influence its mineral composition and biological properties. In addition, no studies have investigated the combined use of *Ulva lactuca* and *Moringa oleifera* as ingredients for producing functional salt. Given that seaweed with a low Na:K ratio may support hypertension-preventive dietary strategies,[6] and that *Moringa oleifera* contains nutrients and bioactive compounds associated with blood pressure regulation, the combination of these materials may offer a promising approach for developing healthier salt alternatives. Therefore, this study evaluated the chemical composition and antioxidant activity of *Ulva lactuca* and *Moringa oleifera* extracts to assess their suitability as functional salt ingredients.

METHODS

Tools. The equipment used in this research was an analytical balance type HP-1/2000 (Sojikyo- Japan), AAS (Atomic Absorption Spectrophotometer) (Shimadzu AA-700), UV-VIS Spectrophotometer (Shimadzu-1800), Oven (Q-Bone).

Materials. The materials used in this research were *Ulva lactuca* seaweed obtained from Trikora Beach, Riau Islands and *Moringa oleifera* leaves obtained from Hang Tuah housing complex, East Tanjungpinang District, Riau Islands Province. Other ingredients used consisted of H_2SO_4 (Merck), HNO_3 (Merck), distilled water, HCl (Merck), ethanol grade pro analysis (PA) 99.9% (Merck), ascorbic acid (Emsure), DPPH (Smart Lab), Neocuproine (Merck).

Sample Preparation

Preparation of seaweed and Moringa leaves

The seaweed is cleaned using sea water from various sand, dirt and other attached plants and then rinsed with fresh water. Moringa leaf preparation was carried out using fresh water then drained. Next, the drying process was carried out on the two samples in the wind for ± 7 - 14 days and continued with drying in the oven for 4 hours at a temperature of 40°C. The dried samples were ground into flour using a blender for ± 30 seconds and continued with sieving using a No. 60 mesh sieve. The results of the sieving were seaweed flour and Moringa leaf flour and then analyzed including chemical composition, heavy metal content, mineral composition, and Na:K mineral ratio.

Extraction of seaweed and Moringa leaves[8]

The next stage was the extraction of each dry sample of seaweed and Moringa leaves, each of which was macerated as much as 50 g with 300 mL of 99.9% PA ethanol solvent for 24 hours. The plant materials were extracted by maceration at a solid-to-solvent ratio of 1:6 (w/v) for 3 days at room temperature (15–30 °C). During the maceration period, the mixture was agitated at least three times daily, in the morning, afternoon, and evening, to facilitate contact between the plant material and the extraction solvent. The extraction process was conducted under light-protected conditions using amber-colored glass bottles or containers completely wrapped in aluminum foil. After completion of the maceration period, the extract was separated from the plant material and concentrated to obtain a dry extract. The resulting dry extract weights were 5.634 g for *Ulva lactuca* and 4.567 g for *Moringa oleifera*, corresponding to extraction yields of 11.268% and 9.134%, respectively. The liquid extract was filtered with a 500-micron cloth and continued filtration with 0.45 µm filter paper (Whatman 42). The liquid extract was evaporated using a rotary vacuum evaporator at a temperature of 50°C. The resulting extract was analyzed for yield, qualitative phytochemistry, and antioxidant activity using the DPPH and CUPRAC methods.

Proximate analysis[9]

Proximate analysis consisting of water, ash, protein, fat, crude fiber and carbohydrate content as well as acid insoluble ash in the extraction of seaweed and Moringa leaves.

Yield analysis

Yield analysis was carried out by comparing the total extract obtained with the amount of raw material used. Yield analysis was carried out with the aim of calculating the percentage of crude extract produced.

Analysis of mineral composition and heavy metal content[10]

Mineral composition analysis consists of calcium, sodium, magnesium, potassium and iron as well as levels of heavy metals lead, mercury, arsenic and cadmium. A 10 g sample was put into an Erlenmeyer, then 5 mL of HNO_3 was added. The mixture was then left in the acid room for 1 hour at room temperature, then heated using a hot plate at 120°C for 4 hours. The mixture was added again with 0.4 mL of H_2SO_4 and heated on a hot plate for ± 1 hour. Add 2-3 drops of solution mixed with HCl and HNO_3 in a 2:1 ratio to the mixture. Next, wait until the mixture changes color from brown to dark yellow and turns to light yellow, then heat it for 10-15 minutes. The mixture is moved and cooled, then add 2 mL of distilled water and 0.6 mL of HCl. The mixture was then heated again for ± 15 minutes. Next, a wet ashing solution is obtained which is then poured into a 100 mL measuring flask with demineralized water. The wet ashing results were then analyzed using an Atomic Absorption Spectrophotometer (AAS) and measurements were made at different wave lengths on mineral and heavy metals.

Phytochemical analysis[11]

Phytochemical testing aims to determine the active compound components contained in green seaweed and Moringa leaves. Phytochemical analysis carried out on each sample included alkaloids, flavonoids, phenols and tannins test (Wagner and Dragendrof).

Analysis of antioxidant activity (2,2-diphenyl-1-picrylhydrazyl (DPPH)[12]

Antioxidant activity testing was carried out using several concentrations of crude extract, including 10, 20, 30, 40 and 50 µg/ml. The standard used is vitamin C (ascorbic acid) using several concentrations including 0,5; 1; 1,5; 2; 2,5; 3 µg/ml. The solution was prepared by reacting 4.5 mL consisting of the diluted sample extract along with the solvent used, then adding 0.5 mL of DPPH, then homogenizing for 30 seconds using a vortex. The mixture was incubated at room temperature and in the dark for 30 minutes. The absorbance of the mixture was measured using a spectrophotometer at a wavelength of 517 nm. A blank solution was also prepared, namely mixing 4.5 mL of ethanol solvent and 0.5 mL of DPPH solution.

Cupric Reducing Antioxidant Capacity (CUPRAC) antioxidant capacity analysis[13]

CUPRAC method antioxidant capacity testing was carried out by preparing 0.3 mL of sample extract and 1 mL each of 0.01 M $CuCl_2 \cdot 2H_2O$; ethanolic neocuproine 0.0075 M; ammonium acetate buffer pH 7 1 M; and 0.8 mL of distilled water. The solution volume was obtained at 4.1 mL, then homogenized using a vortex mixture of samples and reagents, then incubated for 30 minutes at room temperature. Next, the absorbance was measured using a UV-Vis spectrophotometer at a wavelength of 450 nm. The standard used is ascorbic acid at concentrations of 1, 2, 3, 4, and 5 µg/ml. The absorbance results were converted to antioxidant capacity expressed in µmol ascorbic acid/g.

Data Analysis

Antioxidant activity was assessed based on IC_{50} values, with the antioxidant capacity of each extract determined through three replicates. Antioxidant capacity is classified as very strong if the IC_{50} is below 50 µg/mL, strong in the 50–100 µg/mL range, moderate in the 100–250 µg/mL range, weak in the 250–500 µg/mL range, and inactive if the IC_{50} exceeds 500 µg/mL.[6] The IC_{50} value was obtained by analyzing the linear relationship between sample concentration and the percentage of inhibition. Antioxidant activity was calculated using the following formula:

$$\text{DPPH Inhibition (\%)} = \frac{\text{Control Absorbance} - \text{Sample Absorbance}}{\text{Control Absorbance}} \times 100\% \quad [2]$$

The data was analyzed using SPSS software. Subsequently, normality and homogeneity tests were conducted. One-way ANOVA was used to determine whether there were differences in IC_{50} values between the *Ulva lactuca* and *Moringa oleifera* extracts. Finally, the differences in the data were further clarified using Duncan and Tukey tables.

RESULT AND DISCUSSION

Proximate analysis *Ulva lactuca* and *Moringa oleifera*

Proximate analysis consisted of water, ash, protein, fat, crude fiber and carbohydrate content as well as acid insoluble ash in *Ulva lactuca* and *Moringa oleifera* extracts. The Proximate Analysis Test can be seen in **Table 1**. Proximate analysis shows *that Ulva lactuca* and *Moringa oleifera* have different compositions. It was found that the water content in *Ulva lactuca* was 13.27% and *Moringa oleifera* was 25.43%. The higher moisture content observed in *Moringa oleifera* may be related to the water-holding capacity of its leaf tissues and the physiological characteristics of fresh leafy vegetables, which generally contain high amounts of intracellular water.[14] In contrast, the lower moisture

content observed in *Ulva lactuca* may be attributable to more extensive water removal during drying, as drying time and processing conditions are known to significantly influence the residual moisture content of dried seaweed products.[15]

Table 1. Proximate analysis of *Ulva lactuca* and *Moringa oleifera*

Proximate analysis	Result (%)	
	Ulva lactuca	*Moringa oleifera*
Water	13.27 ± 0.03	25.43 ± 0.25
Ash	40.08 ± 0.21	20.69 ± 0.05
Fat	15.19 ± 0.42	29.02 ± 0.27
Proteins	11.73 ± 0.05	17.92 ± 0.08
Carbohydrate	19.73 ± 0.36	6.94 ± 0.02

The ash content in *Ulva lactuca* is 40.08% and *Moringa oleifera* is 20.69%. The high ash content observed in Ulva lactuca indicates a substantial proportion of mineral and inorganic constituents. Seaweeds are known to accumulate considerable amounts of macro- and microelements, including potassium, calcium, magnesium, sodium, sulfates, and phosphates. Consequently, ash content is often used as an indicator of the mineral richness of seaweed biomass and may also be influenced by environmental and habitat conditions.[9] This is perfectly natural, as *Ulva lactuca* is a marine macroalga that naturally absorbs and accumulates minerals (such as calcium, potassium, sodium, magnesium, and iodine) from seawater. *Moringa oleifera* leaves have extensive parenchyma tissue and moist mesophyll, so they easily absorb and store minerals from the soil. *Ulva lactuca* naturally contains high levels of potassium (K), magnesium (Mg), and calcium (Ca), making it a potential ingredient for producing mineral-rich salt alternatives.[16]

The fat content in *Ulva lactuca* is 15.19% and *Moringa oleifera* is 29.02%. The fat content in *Ulva lactuca* is generally lower than *Moringa oleifera*. This is because *Moringa oleifera* stores fat as a reserve energy and components of cell membranes. This indicates that the Moringa in this sample is a highly concentrated source of energy and fatty acids. Fat also plays a role in protecting the body from changes in temperature.[17] Meanwhile, *Ulva lactuca* relies mostly on water-soluble carbohydrates for energy reserves, not fat.[18]

The protein content in *Ulva lactuca* is 11.73% and *Moringa oleifera* is 17.92%. This is because *Moringa oleifera* has photosynthetic tissue (mesophyll) and cells with active nuclei which contain lots of enzymes and structural proteins, differences in seasons, geographical conditions and species so that the protein content is higher than *Ulva Lactuca*. This aligns with the characteristics of the *Moringa oleifera*, which is widely known to be rich in essential amino acids.[19]

The carbohydrate content in *Ulva lactuca* is 19.73% and *Moringa oleifera* is 6.94%. Differences in carbohydrate levels are influenced by geographic conditions, nutrition, habitat and season. In marine algae, the majority of carbohydrates consist of polysaccharides (such as crude fiber, cellulose, and ulvan) that are not easily digested but serve excellently as dietary fiber or gelling agents.[20]

The extract yield was obtained from the extraction of *Ulva lactuca* and *Moringa oleifera*. Extraction is carried out using the maceration method. From the research results, the yield of *Ulva lactuca* extract was 0.8% and *Moringa oleifera* extract was 2%. The color of *Ulva lactuca* extract is slightly brownish green. Meanwhile, the color of *Moringa oleifera* is dark green. The yield of *Ulva lactuca* extract is smaller because more polar compounds dissolve in ethanol solvent compared to non-polar compounds. Other differences that affect the yield of the two extracts are due to differences in raw material habitat, harvest age, simplicia size, extraction temperature, extraction time, raw material and solvent ratio.[20]

Analysis of the mineral composition of *Ulva lactuca* and *Moringa oleifera*

Analysis of the mineral composition of *Ulva lactuca* and *Moringa oleifera* consists of Ca, Na, Mg minerals. K and Fe using AAS. The results of the mineral composition analysis test on *Ulva lactuca* and *Moringa oleifera* can be seen in **Table 2**.

Table 2. Mineral Composition Analysis Test for *Ulva lactuca* and *Moringa oleifera*

Mineral	*Ulva lactuca* (mg/g)	*Moringa oleifera* (mg/g)
Ca	2.47 ± 0.05	6.86 ± 0.24
Na	109.65 ± 0.34	0.79 ± 0.02
Mg	10.84 ± 0.15	0.95 ± 0.03
K	124.24 ± 0.38	5.28 ± 0.21
Fe	0.31 ± 0.15	0.05 ± 0.01
Na : K ratio	0.88 ± 0.14	0.15 ± 0.02

From the research results, it was found that Ca (calcium) levels were greater in *Moringa oleifera* 6.86 mg/g compared to *Ulva lactuca* at 2.47 mg/g. The Ca levels in *Moringa oleifera* are also the highest compared to other minerals. The calcium content is higher in *Moringa oleifera* leaves than in animal milk.[21] Calcium plays an important role in the formation of bones and teeth and regulates cell functions, including blood clotting, muscle contraction, nerve transmission, protecting cell membranes, extracellular and intracellular fluids.[22]

The Na (Sodium) content in *Ulva lactuca* is 109.65 mg/g higher than in *Moringa oleifera* 0.79 mg/g. Na content is really needed by the body to maintain osmotic balance, acid base and body fluids. [23]Na also plays a role in maintaining cell function and transmitting nerve impulses.[6]

The Mg (Magnesium) content in *Ulva lactuca* is 10.84 mg/g higher than in *Moringa oleifera* 0.95 mg/g. The high Mg content is directly proportional to the high ash content in *Ulva lactuca*. This states that the higher the ash content, the higher the mineral content. Magnesium in the body plays a role in helping regulate blood pressure, blood glucose levels, protein synthesis, nerve and muscle function.[2]

The K (Potassium) content in *Ulva lactuca* is 124, 24 mg/g and *Moringa oleifera* is 5.28 mg/g. The high levels of potassium in both samples indicate good results for making seaweed salt. The role of potassium in the body is to balance excess sodium levels in the blood, help balance acids and bases and regulate the osmotic balance of body fluids.[24]

The Fe (Iron) content in *Ulva lactuca* is 0.31 mg/g higher than in *Moringa oleifera* 0.05 mg/g. The iron content in both samples is the smallest compound compared to other minerals. Iron in the blood plays a role in helping produce red blood cells.[6]

The sodium and potassium content of *Ulva lactuca* and *Moringa oleifera* make them suitable additives for healthy or dietary salt formulations. The sodium to potassium (Na:K) ratio is 0.88 for *Ulva lactuca* and 0.15 for *Moringa oleifera* thus, *Ulva lactuca* exhibits a higher ratio of sodium to potassium compared to *Moringa oleifera*. The ideal Na:K ratio is close to 1, a combination of *Ulva lactuca* and *Moringa oleifera* is highly suitable for producing functional or dietary salt for individuals with hypertension. The variations in mineral content between the two samples *Ulva lactuca* and *Moringa oleifera* may be attributed to factors such as species differences, physiological characteristics, and geographical conditions.[4]

Analysis of Heavy Metal Levels in *Ulva lactuca* and *Moringa oleifera*

Pollutants in waters that are very dangerous for living creatures are heavy metal contamination. Heavy metals are toxic and carcinogenic. Heavy metals can damage the ecosystem in these waters. The heavy metal content test consists of Pb, Hg, As and Cd. Heavy metal levels in both samples can be seen in **Table 3**.

Table 3. Analysis of Heavy Metal Levels in *Ulva lactuca* and *Moringa oleifera*

Parameter	*Ulva Lactuca* (mg/kg)	*Moringa oleifera* (mg/kg)
Pb	0.66 ± 0.03	0.15 ± 0.01
Hg	0.70 ± 0.06	0
As	106.28 ± 0.28	0
Cd	1.08 ± 0.05	0

The levels of heavy metals including Pb, Hg, As and Cd in *Ulva lactuca* exceed standards. The high metal levels may be due to waste disposal activities in public places but reaching places where *Ulva lactuca* grows. Rainfall may also affect heavy metal levels in water areas. Heavy metals enter the waters through rain through a crystallization process in the air. If heavy metals enter the water, they will be absorbed by the seaweed cell walls. Heavy metal levels in *Ulva lactuca* can also be caused by marine transportation fuel.[25]

Heavy metals are toxic because they can cause damage to nerves, affect brain development in children, anemia and the formation of red blood cells. Arsenic is a heavy metal that can damage the kidneys and liver.[26] Washing the *Ulva lactuca* extract samples was carried out repeatedly and continued with the drying process. Then, in making the extract to obtain the filtrate which will later be used as seaweed salt, a filtering process is carried out. The residual part of the filtering results may contain heavy metals. Heavy metal levels can decrease if processed into food.[2]

Phytochemical Test

Phytochemical tests are carried out with the aim of determining the content of bioactive compounds contained in plants and which have an important role in human health.[6] Phytochemical tests on *Ulva lactuca* and *Moringa oleifera* are carried out by looking at color changes or the presence of precipitates formed due to the influence of the reagents

given. Phytochemical tests carried out on the extract *Ulva lactuca* and *Moringa oleifera* were alkaloids, flavonoids, phenols, and tannins.

Qualitative phytochemical screening indicated the presence of alkaloids, flavonoids, phenolic compounds, and tannins in *Ulva lactuca* and *Moringa oleifera* extracts. These phytochemical groups are relevant to food, pharmaceutical, cosmetic, and biomedical applications and have been associated with antioxidant and immunomodulatory effects. The potential anticoagulant activity of *Ulva lactuca*, however, is more appropriately linked to sulfated polysaccharides such as ulvan and should be confirmed using a specific coagulation assay.[27]

Analysis of Antioxidant Activity and Capacity

The antioxidant activity and capacity of *Ulva lactuca* and *Moringa oleifera* extracts were evaluated using the DPPH method for antioxidant activity and the CUPRAC method for antioxidant capacity, with three replicates performed for both methods.

In the antioxidant activity assay, Vitamin C (ascorbic acid) served as the positive control or standard solution at concentrations of 0.5, 1, 1.5, 2, 2.5, and 3 µg/ml. Subsequently, diluted solutions of *Ulva lactuca* and *Moringa oleifera* extracts were prepared; 0.5 mL of DPPH solution was added to each, and the mixtures were homogenized for 30 seconds before being incubated for 30 minutes. Absorbance was measured using a spectrophotometer at a wavelength of 517 nm. A control solution was also prepared by mixing 4.5 mL of ethanol solvent with 0.5 mL of DPPH solution.

Antioxidant activity is expressed in terms of IC_{50}. The IC_{50} value represents the concentration of the test compound required to scavenge 50% of free radicals. The antioxidant activity assay utilizes a calibration curve based on an ascorbic acid standard solution. The calibration curve is shown in **Figure 1**. The sample concentration and percentage inhibition are plotted on the x axis and y axis, respectively, of the linear regression equation, which is expressed as y = ax + b. A correlation coefficient (R) of 0.9818 was obtained, indicating good linearity (R > 0.9).

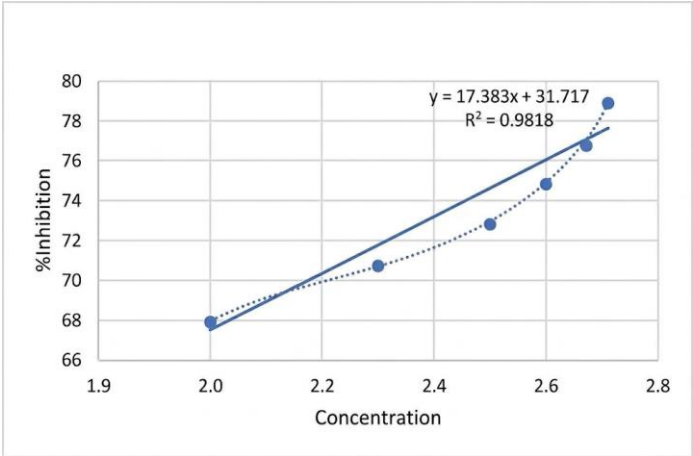


Figure 1. Standard Calibration Curve of Ascorbic Acid.

The DPPH assay yielded IC_{50} values of 11.265 µg/mL for *Ulva lactuca* extract and 6.828 µg/mL for *Moringa oleifera* extract, indicating very strong free-radical scavenging activity. The IC_{50} value represents the concentration required to inhibit 50% of DPPH radicals. Based on commonly used antioxidant classifications, IC_{50} values below 50 µg/mL are categorized as very strong antioxidant activity.[28] Both *Ulva lactuca* and *Moringa oleifera* contain bioactive phytochemicals with documented antioxidant potential, suggesting that these extracts may serve as promising natural sources of antioxidant compounds for food, nutraceutical, and pharmaceutical applications.[17,27]

Moringa oleifera is rich in phenolic compounds and flavonoids that are highly rapid and efficient at donating hydrogen atoms to "scavenge" free radicals, as evidenced by its potent DPPH IC_{50} value. In contrast, *Ulva lactuca* is rich in sulfated polysaccharides, marine pigments, and specific peptides that show low reactivity in the DPPH assay but possess exceptionally strong electron-donating capacity in the metal reduction assay (CUPRAC).[6]

The very strong antioxidant activity observed in both extracts is likely related to the presence of phenolic compounds, flavonoids, tannins, and other bioactive metabolites identified during phytochemical screening.[29,30] The use of ethanol as the extraction solvent may have facilitated the recovery of these antioxidant-active compounds.[31]

The antioxidant activity measured by the DPPH method can also be observed through the color change from purple to yellow. This indicates the ability of active compounds in the sample to scavenge free radicals via electron transfer. If the purple color fades further and changes to yellow-brown, it means that more electrons are being donated, and the antioxidant activity of the extract is stronger.[6]

The antioxidant capacity measured using the CUPRAC method showed that the extract of *Ulva lactuca* was 55.849 ± 5.59 µmol ascorbic acid/g extract while the extract of *Moringa oleifera* was 0.013 ± 2.35µmol µmol ascorbate/g extract. Based on these results, the antioxidant capacity of the *Ulva lactuca* extract is higher than that of *Moringa oleifera*. A higher CUPRAC value indicates stronger antioxidant activity.[6] In the CUPRAC method, the bis-neocuproine–copper (II) complex acts as a reagent that oxidizes antioxidant compounds in the extract and is reduced to the bis-neocuproine–copper (I) compound. The CUPRAC reagent is selective due to its low reduction potential. The principle of CUPRAC antioxidant capacity is based on the ability to reduce the Cu^{2+} complex (blue turquoise) to Cu^{1+}Nc (yellow), which occurs through electron donation.[6] Variations in antioxidant activity among samples may be explained by differences in processing and cultivation conditions. Drying temperature can influence the stability of phenolic compounds and flavonoids, whereas growth location and salinity may affect the biosynthesis and accumulation of bioactive metabolites.[8,30] Consequently, extracts obtained from the same species may exhibit different antioxidant capacities depending on environmental and processing factors.[29]

Limitation

The presence of heavy metals in *Ulva lactuca* extracts obtained from Bintan waters poses a challenge for further research. Lead compounds are toxic, as they can cause nerve damage, impair brain development, and lead to anemia and disruptions in red blood cell formation. Therefore, further research involving various marine plant species from different waters is required.

CONCLUSION

A combination of *Ulva lactuca* and *Moringa oleifera* extracts was evaluated to determine their sodium and potassium levels for use as additives in salt formulation. An ideal sodium-to-potassium ratio for dietary salt management in hypertension is close to 1.0. The study found sodium-to-potassium ratios of 0.88 for *Ulva lactuca* and 0.15 for *Moringa oleifera*. Tests of antioxidant activity and capacity indicated that both *Ulva lactuca* and *Moringa oleifera* possess very strong free radical scavenging capabilities. These characteristics support their potential development as functional low-sodium, potassium-enriched salt products that may contribute to healthier dietary strategies for hypertension prevention and management.

FUNDING

This research was supported by grant funds for Beginner Lecturer Research, National Competitive Research in 2025 based on Decree Number 0070/C3/AL.04/2025 and Agreement/Contract Number 042/LL17/DT.05.00/PL/2025.

ACKNOWLEDGMENTS

Thank you to the institutions that have helped carry out this research, namely Stikes Hang Tuah Tanjungpinang and Raja Maritim Ali Haji University (UMRAH).

THE GENERATIVE AI DISCLOSURE STATEMENT

The authors confirm that no Generative Artificial Intelligence (AI) was used in the drafting, data analysis, or preparation of this manuscript.

AUTHOR CONTRIBUTION STATEMENT

Ikha Rahardiantini: Conceptualization, Methodology, Conduct The Study, Writing Original Draft Preparation. **Lili Sartika**: Writing-Editing. **Masyitah Novia Yanti**: Data Curation and Validation, Writing-Reviewing.

CONFLICT OF INTEREST DECLARATION

The authors declare no conflict of interest.

REFERENCES

1. Penalver R, Lorenzo JM, Ros G, Amarowicz R, Pateiro M, Nieto G. Seaweeds as a functional ingredient for a healthy diet. *Marine Drugs*. MDPI AG; 2020. doi:10.3390/md18060301
2. Nurjanah N, Ramlan R, Jacoeb AM, Seulalae AV. Komposisi Kimia Tepung dan Aktivitas Antioksidan Ekstrak Ulva lactuca dan Genjer (Limnocharis flava) Sebagai Bahan Baku Pembuatan Garam Rumput Laut [Chemical Composition of Flour and Antioxidant Activity of Extract Ulva lactuca and Genjer (Limnocharis flava) as Raw Materials for the Production of Seaweed Salt]. *Jurnal Pascapanen dan Bioteknologi Kelautan dan Perikanan*. 2023 Jun 30;18(1):63. https://jurnal.kkp.go.id/jbpkp/en/article/view/21221
3. World Health organization. *Sodium intake for adults and children*. In: Guideline. 2012. https://www.who.int/publications/i/item/9789241504836
4. Rodrigues D, Freitas AC, Pereira L, Rocha-Santos TAP, Vasconcelos MW, Roriz M, Rodriguez-Alcala LM, Gomes AMP, Duarte AC. Chemical composition of red, brown and green macroalgae from Buarcos bay in Central West Coast of Portugal. *Food Chem*. 2015 Oct 1;183:197–207. doi:10.1016/j.foodchem.2015.03.057.
5. Yanti E. Pengaruh Pemberian Rebusan Daun Kelor (Moringa Olifiera) Terhadap Tekanan Darah Pada Penderita Hipertensi [The Effect of Moringa Leaves on Blood Pressure in Patients with Hypertension]. *JIK : Jurnal Ilmu Kesehatan*. 2019 Apr 25;3(1). doi:10.33757/jik.v3i1.164
6. Nurjanah N, Abdullah A, Nufus C. Karakteristik Sediaan Garam Ulva lactuca dari Perairan Sekotong Nusa Tenggara Barat bagi Pasien Hipertensi [Characteristics of Ulva lactuca from Sekotong West Nusa Tenggara as seaweed salt preparation for hypertensive patients]. *J Pengolah Has Perikan Indones*. 2018 Apr 25;21(1):109. doi:10.17844/jphpi.v21i1.21455
7. Zebua D, Sunarti S, Harahap A, Ningsih F, Zalukhu A, Masrini M. Rebusan Daun Kelor Berpengaruh terhadap Tekanan Darah Penderita Hipertensi [Moringa Leaf Decoction Effects on Blood Pressure of Hypertension Patients]. *Jurnal Penelitian Perawat Profesional*, 2021;3(2):399-406. doi:10.37287/jppp.v3i2.470
8. Pappou S, Dardavila MM, Savvidou MG, Louli V, Magoulas K, Voutsas E. Extraction of Bioactive Compounds from Ulva lactuca. *Applied Sciences*. 2022; 12(4):2117. doi:10.3390/app12042117.
9. Rasyid A. Evaluation of Nutritional Composition of The Dried Seaweed Ulva lactuca from Pameungpeuk Waters, Indonesia. *Tropical Life Sciences Research*. 2017;28(2):119-125. doi:10.21315/tlsr2017.28.2.9
10. Latimer GW, Jr. *Official Methods of Analysis of AOAC International*. 21st ed. AOAC International; 2019.
11. Harborne JB, Kosasih P dan Iwang SJ. *Metode Fitokimia Penuntun Cara Modern Menganalisis Tumbuhan*. 2nd ed. ITB Press; 1987.
12. Sumarni F, Saleh C, Pratiwi DR. Uji Fitokimia dan Uji Aktivitas Antioksidan (Metode DPPH) dari Daun Biriba (Rollinia mucosa (Jacq.) Baill.) [Phytochemical Test and Antioxidant Activity (DPPH Method) from Leaves of Biriba (Rollinia mucosa (Jacq.) Baill.)]. *Jurnal Atomik*. 2019;4(1):9-13. https://jurnal.kimia.fmipa.unmul.ac.id/index.php/JA/article/view/679
13. Kurnia D, Rohmah D, Anggraeni VJ. Aktivitas antioksidan dengan metode cuprac dan penetapan kadar fenolat total pada ekstrak dan fraksi makroalga Eucheuma cottonii [Antioxidant activity using the cuprac method and determination of total phenolate content in the extract and fraction of macroalgae Eucheuma cottonii]. *Jurnal Agrotek Ummat*. 2022;9(4):298–309. https://journal.ummat.ac.id/index.php/agrotek/article/view/11116
14. Ortolá MD, Castelló ML, Etchevers MC, García-Mares FJ, Soriano MD. Physicochemical Properties of Moringa oleifera Leaves Grown in Valencian Community (Spain). *Biology and Life Sciences Forum*. 2021; 8(1):4. doi:10.3390/blsf2021008004
15. Ramadhan W, Sitepu NKB, Salmiragga TS, Fauzan MN, Hardiningtyas SD, Kurnia KA, Pari RF, Wijayanta AT. Effect of Ultrasound-Assisted Vacuum Drying on Moisture Transport Behavior and Physicochemical Properties of Nori-like Products Prepared from Green Laver (Ulva lactuca). *Food Biophysics*. 2025;20:102. doi:10.1007/s11483-025-09993-4.
16. Sultana S. Nutritional and functional properties of Moringa oleifera. *Metabol Open*. 2020 Dec;8:100061. doi:10.1016/j.metop.2020.100061
17. Athira KA, Panjikkaran ST, Aneena ER, Sharon CL, Pathrose B, Gopal KS, Lakshmi PS. Moringa oleifera - Proximate and Anti-nutritional Composition. *The Indian Journal of Nutrition and Dietetics*, 2021;58(3), 390–397. doi:10.21048/IJND.2021.58.3.27629
18. Costa MM, Pio LB, Bule P, Cardoso VA, Duarte M, Alfaia CM, Coelho DF, Bras JA, Fontes CMGA, Prates JAM. Recalcitrant cell wall of Ulva lactuca seaweed is degraded by a single ulvan lyase from family 25 of polysaccharide lyases. *Animal Nutrition*. 2022 Jun 1;9:184–92. doi:10.1016/j.aninu.2022.01.004

19. Masitlha EP, Seifu E, Teketay D. Nutritional composition and mineral profile of leaves of Moringa oleifera provenances grown in Gaborone, Botswana. *Food Production, Processing and Nutrition*. 2024 Dec 1;6(1). doi:10.1186/s43014-023-00183-8

20. Monteiro Vasconcelos MM, Vollet Marson G, Turgeon SL, Tamigneaux É, Beaulieu L. Physicochemical properties of wild and cultivated Saccharina latissima macroalgae harvested in the Canadian boreal-subarctic transition zone. *Heliyon*. 2024 Apr 30;10(8). doi:10.1016/j.heliyon.2024.e29626

21. Yun YR, Oh SJ, Lee MJ, Choi YJ, Park SJ, Lee MA, Min SG, Seo HY, Park SH. Antioxidant activity and calcium bioaccessibility of Moringa oleifera leaf hydrolysate, as a potential calcium supplement in food. *Food Sci Biotechnol*. 2020 Nov 1;29(11):1563–71. doi:10.1007/s10068-020-00820-9

22. Pujiastuti DY, Ghoyatul Amin MN, Alamsjah MA, Hsu JL. Marine organisms as potential sources of bioactive peptides that inhibit the activity of angiotensin I-converting enzyme: A review. *Molecules*. MDPI AG; 2019;24(14):2541. doi:10.3390/molecules24142541.

23. Bernal A, Zafra MA, Simón MJ, Mahía J. Sodium Homeostasis, a Balance Necessary for Life. *Nutrients*. MDPI; 2023;15(2):395. doi:10.3390/nu15020395.

24. Culver SA, Suleman N, Kavuru V, Siragy HM. Renal Hypokalemia: An Endocrine Perspective. *Journal of Clinical Endocrinology and Metabolism*. Endocrine Society; 2024;109(7):1694–706. doi:10.1210/clinem/dgae201.

25. Azizah R, Malau R, Susanto AB, Santosa GW, Hartati R, Irwani I, Suryono S. Kandungan Timbal pada Air, Sedimen, dan Rumput Laut Sargassum sp. di Perairan Jepara, Indonesia [Concentration of Lead in the Seawater, Sediment, and the Seaweed Sargassum sp.in JeparaWaters, Indonesia]. *Jurnal Kelautan Tropis*. 2018 Dec 7;21(2):155-166. doi:10.14710/jkt.v21i2.3010

26. Concessao PL, Prakash J. Arsenic-induced nephrotoxicity: Mechanisms, biomarkers, and preventive strategies for global health. *Vet World*. 2025 Jul;18(7):2136–2157. doi:10.14202/vetworld.2025.2136-2157

27. Putra NR, Fajriah S, Qomariyah L, Dewi AS, Rizkiyah DN, Irianto I, Rusmin D, Melati M, Trisnawati NW, Darwati I, Arya NN. Exploring the potential of Ulva Lactuca: Emerging extraction methods, bioactive compounds, and health applications – A perspective review. *S. Afr. J. Chem. Eng*. 2024 Jan;47:233-245. doi:10.1016/j.sajce.2023.11.017

28. Molyneux P. The use of the stable free radical diphenylpicrylhydrazyl (DPPH) for estimating antioxidant activity. *Songklanakarin J. Sci. Technol*. 2004;26(2):211-219. https://sjst.psu.ac.th/article/214

29. Camilleri E, Blundell R. A comprehensive review of the phytochemicals, health benefits, pharmacological safety and medicinal prospects of Moringa oleifera. *Heliyon*. 2024;10(6):1-16. doi:10.1016/j.heliyon.2024.e27807

30. Mutavski Z, Jerković I, Nikolić NĆ, Radman S, Flanjak I, Aladić K, Šubarić D, Vulić J, Jokić S. Comprehensive Phytochemical Profiling of Ulva lactuca from the Adriatic Sea. *Int. J. Mol. Sci.*. 2024; 25(21):11711. doi:10.3390/ijms252111711

31. Yusoff IM, Taher ZM, Rahmat Z, Chua LS. A review of ultrasound-assisted extraction for plant bioactive compounds: Phenolics, flavonoids, thymols, saponins and proteins. *Food Res. Int.*. 2022;157(111268):1-17. doi:10.1016/j.foodres.2022.111268