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The Potency of *Ulva reticulata* as Natural Flavoring to Prevent Hypertension

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ABSTRACT

Ulva reticulata is a widespread species of green algae found in the waters of Sumba, Indonesia. However, its utilization remains limited. *U. reticulata* has shown a promise as a flavoring powder for individuals with hypertension. This study involved two treatments: one without maltodextrin (treatment A) and one with maltodextrin (treatment B). The resulting flavored powders were analyzed for proximate characteristics, water activity, amino acids, minerals, sodium chloride content, yield, and heavy metal concentration. The results showed that the moisture content for treatments A and B was 12.69 and 9.13%, respectively. The ash content was 62.17% for treatment A and 7.19% for treatment B. Both treatments contained 0.02% fat, while protein content was 3.87% for treatment A and 0.85% for treatment B. Carbohydrate content was 1.26% in treatment A and 82.83% in treatment B. Water activity was measured at 0.46 for treatment A and 0.48 for treatment B, with yields of 6% and 10%, respectively. The amino acid profile detected in treatment A included 15 amino acids: alanine, arginine, aspartic acid, glycine, glutamic acid, histidine, isoleucine, leucine, lysine, valine, phenylalanine, proline, serine, threonine, and tyrosine. In treatment B, only alanine, arginine, aspartic acid, glycine, and glutamic acid were detected. The amino acids with the highest concentrations in both treatments were aspartic acid (2512.98ppm in treatment A and 613.65ppm in treatment B) and glutamate (3369.06ppm in treatment A and 1074.38ppm in treatment B). Furthermore, the highest mineral levels in both treatments were found for chloride, magnesium, potassium, and sodium, with Na/K ratios of 1.38 and 1.42. The flavoring powder derived from *U. reticulata* had sodium chloride levels below 60%, confirming the absence of heavy metals. The findings of this study suggest that *U. reticulata* flavoring powder has the potential to be a healthy substitute for salt, which may help prevent hypertension.

INTRODUCTION

Hypertension is a significant global health problem that affects approximately 1.13 billion people worldwide **(Mills *et al.*, 2020)**. Hypertension is caused by cardiovascular abnormalities, which can significantly increase the risk of heart disease, stroke, and other health complications **(Zhou *et al*., 2021)**. Traditionally, antihypertensive drugs have been effective in preventing hypertension. However, they may induce adverse effects that might impact overall health **(Silva *et al*., 2019)**. Therefore, alternative efforts are required to explore natural compounds that have garnered interest in recent times.

Seaweed is regarded as a desirable nutritional element in diet due to its low lipid content, high levels of polysaccharides, fiber, and polyunsaturated fatty acids (PUFAs) that offer health benefits **(Ganesan *et al*., 2019)**. Furthermore, seaweed also has primary and secondary metabolites. Primary metabolites in seaweed consist of proteins, polysaccharides, and lipids, while secondary metabolites contain phenolic compounds, halogenated compounds, sterols, terpenes, and small peptides **(Fernando *et al*., 2020)**. Seaweed has a protein level ranging from 10-47%, which has been found to provide advantages in combating many health conditions such as oxidative stress, cancer, and hypertension **(Wada *et al*., 2011; Leong *et al*., 2024)**. Furthermore, seaweed possesses a significant concentration of minerals and can serve as a mineral additive in food supplements **(Rupérez, 2002; Tarigan *et al*., 2024)**.

Seaweed is a new generation of nutritional supplements that can serve as natural compounds to prevent hypertension **(Ghuzman *et al.*, 2018; Peñalver *et al*., 2020; Kumari *et al*., 2023)**. Seaweeds are reported to have primary and secondary metabolites that have the potential to be developed as seaweed salts or flavoring powders **(Jacoeb & Abdullah, 2020; Gullón *et al*., 2021; Notowidjojo *et al*., 2021; Meiyasa *et al*., 2023; Meiyasa *et al*., 2024)**. Previous studies have reported that some seaweed species are being explored as salts or flavors. For example, functional salt from *Ulva lactuca* seaweed has been used for people with hypertension **(Nurjanah *et al*., 2018; Nurjanah *et al*., 2019)**. *Sargassum polycystum*, *U. lactuca,* and *Caulerpa lentilifera* seaweeds have been developed as seaweed salts **(Nomleni *et al*., 2023; Seulalae *et al*., 2023)**. The development of seaweed as a salt or flavor enhancer is attributed to the presence of amino acids that contribute to the umami taste, such as aspartic acid and glutamate **(Frøst *et al.*, 2021; Meiyasa *et al*., 2023)**.

One type of seaweed species with the potential to be used as a flavoring seasoning is *Ulva reticulata*. This species is known to inhabit numerous Indonesian waters, including the Sumba waters **(Meiyasa *et al*., 2020; Tarigan, 2020)**. *U. reticulata* has a fairly high protein content (10.68%), high mineral content, contains secondary metabolites, and has strong antioxidant activity, which has potential health benefits, including antihypertensive effects **(Kumari *et al*., 2023; Tarigan *et al*., 2023; Meiyasa *et al*., 2024)**. Studies have shown that bioactive peptides and polysaccharides found in seaweeds exhibit significant angiotensin-converting enzyme (ACE) inhibitory activity, which is a key mechanism in blood pressure regulation **(Wijesekara & Kim, 2010)**.

Seaweed is rich in minerals such as Na, K, Mg, P, I, Zn, and Fe. This makes seaweed a suitable alternative to salt (NaCl) for reducing sodium intake **(Cardoso *et al*., 2015;**

Circuncisão *et al*., 2018; Lozano- Muñoz *et al*., 2020; Dassa & Meiyasa *et al*., 2023). Some types of seaweeds have high Na and K contents but low Na/K ratios. Seaweeds possess nutritional components that can serve as therapeutic agents for human health **(Cho *et al*., 2019; Cho *et al*., 2022)**. In addition, minerals contained in seaweed can be used as substitutes for salt to reduce NaCl salt intake **(Circuncisão *et al*., 2018; Lozano Muñoz & Díaz, 2020)**. Therefore, the purpose of this study was to evaluate the potential of *U. reticulata* as a flavoring powder to prevent hypertension.

MATERIALS AND METHODS

1. Sample collection

Ulva reticulata samples were obtained from the waters of Moudolung, East Sumba Regency, East Nusa Tenggara Province, Indonesia.

2. Preparation of *Ulva reticulata*

U. reticulata samples obtained from Moudolung waters were cleaned of impurities, such as sand and coral reefs, and then brought to the laboratory for drying. The drying process of *U. reticulata* was carried out by aerating for seven days **(Djoh *et al*., 2024)**. The dried *U. reticulata* samples were then used to produce *U. reticulata*-flavoring products.

3. Production of *Ulva reticulata* flavoring powder product

This procedure was performed by following the studies of **Nurjanah *et al*. (2018)**, **Septiyani *et al*. (2020)** and **Kadaryati *et al*. (2021)**. This study consisted of two treatments: treatment without the addition of maltodextrin and spices (treatment A) and treatment with the addition of maltodextrin and spices (treatment B). The dehydrated *U. reticulata* sample was measured to weigh 500g. Then, 1000mL of distilled water in a 1:2 ratio was added to the sample. The mixture was heated in a water bath with a magnetic stirrer at 60°C for 30 minutes. Treatment A did not contain maltodextrin and spices, while treatment B contained spices (1% garlic, 1% pepper powder, 0.2% sugar, 0.2% brown sugar, and 2.5% maltodextrin). The extracts were then filtered using filter paper and dried at 80°C for 22h. Pulverization was performed using a blender to produce a uniform particle size. The resulting *U. reticulata* flavoring powder was tested for proximate, water activity, amino acid profile, minerals, and heavy metals.

4. The test parameter

4.1 Proximate

The resulting *U. reticulata* flavoring powder was tested for proximate contents such as moisture, ash, fat, protein **(AOAC, 2005)**, and carbohydrate (by difference).

4.2 Water activity

Analysis of water activity in *U. reticulata* flavoring powder was carried out using an aw meter. The procedure was to put the sample into the container on the aw meter, and then let it stand for 15min.

4.3 Amino acid profile

Amino acid profile analysis of *U. reticulata* flavoring powder was performed using Ultra-Performance Liquid Chromatography (UPLC) 18-5-17/MU/SMM-SIG **(Waters, 2012)**.

4.4 Minerals

Mineral testing consisted of sodium (Na), magnesium (Mg), chloride (Cl), potassium (K), manganese (Mn), zinc (Sn), and iron (Fe). The test was carried out by mixing 10g of sample and 5mL of HNO_3 in an Erlenmeyer flask. The mixture was allowed to stand for 1h at room temperature in the acid chamber and was heated with a hot plate at 120°C for 4h. Next, 0.4mL of H_2SO_4 was introduced, and the mixture was heated on a hot plate for approximately 1 hour. The mixture was subsequently combined with 2-3 drops of a solution containing a mixture of HCl and HNO_3 in a 2:1 ratio. The addition continued until the mixture underwent a color shift from brown to dark yellow and turned light yellow. Following the occurrence of a color change, the heating was prolonged for 10-15 minutes. The sample was removed and cooled, and 2mL of distilled water and 0.6mL of HCl was added. The mixture was heated again for approximately 15 minutes to facilitate dissolution. The resulting wet ignition solution was then measured in a 100mL measuring flask using demineralized water. An atomic absorption spectrophotometer (AAS) was used to assess the results of wet shaving. The wavelengths for mineral analysis were as follows: sodium at 589.6 nm, magnesium at 285.2 nm, potassium at 766.5 nm, manganese at 279.5 nm, zinc at 213.88 nm, and iron at 248.3 nm. Chloride analysis was conducted using the titrimetric method (18-11-7/MU/SMM-SIG).

4.5 Salt content (NaCl)

The analysis of the sodium chloride (NaCl) level in *U. reticulata* flavoring powder was conducted according to SNI 3556:2016. A sample of 5g was added to 200mL in a 500mL volumetric flask, and the sample was filtered using filter paper. The filter water and filter paper were washed with distilled water (1x spray) and then diluted with a few drops of 1 N H_2SO_4 until the solution exhibited an acidic reaction with the phenolphthalein indicator, neutralized with 4 N NaOH, and diluted with distilled water to 100mL. The sample was added to 1mL of 5% K_2CrO_4 solution and diluted with 0.1 N $AgNO_3$ solution until a brick-red color was formed. The percentage of NaCl was calculated using the following formula:

$$\mathrm{NaCl} = \frac{\mathrm{V \ x \ N \ x \ FP \ x \ 5.58}}{\mathrm{W}} \mathrm{\ x \ 100}$$

Description:

V = volume of $AgNO_3$ required in the titration (mL)

N = normality of $AgNO_3$ (N)

FP = dilution factor

58.5 = molecular weight of NaCl
W = sample weight (mg)

4.6 Heavy metals

Heavy metal analysis of *Ulva reticulata* flavoring powder included mercury (Hg) and lead (Pb) using AAS. The wavelengths used for each heavy metal were Pb and Hg of 283.3 and 253.6nm, respectively, with detection limits of 0.004 and 0.004mg/ kg, respectively.

4.7 Yield

The yield of *Ulva reticulata* flavoring powder was calculated based on the following formula:

$$\text{Yield of flavouring powder} = \frac{\text{the weight of flavouring powder}}{\text{simplisia } Ulva\ reticulata} \times 100$$

5. Data analysis

The resulting data were analyzed descriptively using Microsoft Excel, and all data were presented as the mean.

RESULTS

1. Chemical composition of *U. reticulata* flavoring powder

Natural flavoring from *U. reticulata* was tested for chemical composition (moisture, ash, fat, protein, and carbohydrate), water activity, and yield. Table (1) demonstrates that the chemical compositions of natural flavoring derived from *U. reticulata* change between treatment A and treatment B. The study findings indicated that treatment A exhibited greater levels of water, ash, and protein content compared to treatment B. Treatment B had a higher carbohydrate content compared to treatment A.

Table 1. Chemical composition, water activity, and yield of *U. reticulata* flavoring powder

Parameter	Chemical composition (%), Water activity (Aw), and Yield (%)	
	Treatment A	Treatment B
Moisture	12.69±0.21	9.13±0.24
Ash	62.17±0.07	7.19±0.02
Lipid	0.02±0.20	0.02±0
Protein	3.87±0.09	0.85±0.02
Carbohydrate	1.26±0.19	82.83±0.24
Water activity (A_w)	0.46±0.01	0.48±0.01
Yield	6±0.01	10±0.01

2. Water activity (Aw)

The findings indicated that the *U. reticulata* flavoring powder in treatment A and treatment B had respective values of 0.46 and 0.48 (Table 1).

3. Yield

The yield of *U. reticulata* flavoring powder was 6% for treatment A and 10% for treatment B, as shown in Table (1).

4. Amino Acid profile of *U. reticulata* flavoring powder

Treatment A had the lowest amino acid composition of histidine (636.21ppm), and the highest was glutamic acid and aspartic acid (3369.06 and 2512.98ppm). In treatment B, the detected amino acids were alanine (666.21ppm), arginine (1405.22ppm), aspartic acid (613.56ppm), glycine (496.75ppm), and glutamic acid (1074.38ppm) (Table 2).

Table 2. Amino acid profile of natural flavoring from *Ulva reticualata*

Amino acid profile (ppm)	Treatment A	Treatment B
L-Alanine	2115.94 ±2.29	666.21±0.33
L-Arginine	2255.64±6.79	1405.22±0.87
L-Aspartic Acid	2512.98±3.85	613.65±3.16
L-Glycine	1938.26±1.85	496.75±0.97
L-Glutamic Acid	3369.06±2.03	1074.38±1.53
L-Histidine	636.21±0.55	Nd
L-Isoleucine	1079.79±0.66	Nd
L-Leucine	1702.39±2.16	Nd
L-Lysine	950.12±0.97	Nd
L-Valine	1446.03±2.67	Nd
L-Phenylalanine	1151.07±1.58	Nd
L-Proline	899.91±2.08	Nd
L-Serine	1163.04±2.03	Nd
L-Threonine	1265.84±0.22	Nd
L-Tyrosine	800.51±0.05	Nd

5. Minerals of *U. reticulata* flavoring powder

The findings indicated that treatment A had the highest average mineral value in comparison with treatment B. The presence of maltodextrin in the *U. reticulata* flavoring powder leads to a reduction in mineral content, resulting in a difference in mineral values. The highest mineral content in treatment A was chloride (806.92ppm), followed by magnesium (692.95ppm), sodium (650.17ppm), potassium (470.93ppm), iron (2.21ppm), manganese (1.27ppm), and zinc (0.04ppm). In contrast, the addition of maltodextrin reduced the mineral content in the *U. reticulata* flavoring powder to the following levels: potassium (64.76ppm), sodium (92.29ppm), chloride (79.34ppm), magnesium (92.72ppm), manganese (0.31ppm), iron (0.52ppm), and zinc (0.01ppm) (Table 3).

Table 3. Minerals of *U. reticulata* flavoring powder

Minerals	Treatment A	Treatment B
Potassium (ppm)	470.93±1.83	64.76±3.35
Sodium (ppm)	650.17±2.65	92.29±0.93
Na:K ratio	1.38	1.42
Chloride (ppm)	806.92±1.91	79.34±1.11
Magnesium (ppm)	692.95±2.18	92.72±0.32
Manganese (ppm)	1.27±0.04	0.31±0.03
Iron (ppm)	2.21±0.07	0.52±0.05
Zinc (ppm)	0.04±0.00	0.01±0.00
NaCl (%)	10.97±0.05	1.13±0.10

6. Heavy metals of *U. reticulata* flavoring powder

The heavy metals analyzed in this study were Hg and Pb. The objective of heavy metal analysis is to verify the absence of heavy metal contamination in the product. The findings indicated that both treatments A and B of *U. reticulata* flavoring powder exhibited no presence of heavy metal contamination (Table 4).

Table 4. Heavy metals of *U. reticulata* flavoring powder

Heavy metals	Treatment A	Treatment B
Mercury (ppm)	Nd	Nd
Lead (ppm)	Nd	Nd

DISCUSSION

Ulva reticulata flavoring products undergo proximate testing to determine their moisture, ash, lipid, protein, and carbohydrate contents. Moisture content analysis is linked to the product's shelf life. A higher moisture content leads to a shorter shelf life due to microbial activity that may damage the product. The study findings indicate that the moisture content was significantly low, below 15%, resulting in an extended shelf life for *U. reticulata* natural flavoring products. The low moisture content in *U. reticulata* natural flavoring products is due to the influence of temperature and the length of time of the product manufacturing process. However, treatment A had a higher moisture content (12.69%) compared to treatment B (9.13%). The filler (maltodextrin) used is responsible for the difference in moisture content, as it is hygroscopic and can bind water. This is in line with the report of **Wahyuni *et al*. (2021)** concerning the impact of the addition of maltodextrin on reducing the moisture content of the instant seasoning product, curry tempoyak powder. Furthermore, **Ardiani and Rahmayanti (2022)** also reported that the addition of maltodextrin to oyster mushrooms can reduce moisture content. Similarly, the addition of maltodextrin can reduce the moisture content of oyster mushroom powder **(Johanes & Setijawaty, 2023)**. Comparatively, the ash content in treatment A exhibited a significantly higher value (62.17%) compared to treatment B (7.19%). **Tarigan *et al*. (2023)** found that *U. reticulata* from Maudolung waters in East Sumba had a significant ash concentration of 36%, which is responsible for the elevated ash content in treatment A.

Furthermore, the process of extracting *U. reticulata* led to a significant increase in the ash content. The high ash content of *U. reticulata* flavoring powder is a result of the minerals being liberated from the seaweed cell wall during the extraction process. This is different from the addition of maltodextrin as a filler in *U. reticulata* flavoring powder, which has a very low ash content of 7.19%. The addition of maltodextrin in large amounts contributed to the decrease in other components, including ash content. This is in accordance with the report conducted by **Yanti *et al*. (2022)** who elucidated that the addition of maltodextrin to a ginger powder drink can reduce the ash content. **Agustina *et al*. (2019)** have observed that the addition of maltodextrin in phycocyanin powder can decrease the amount of ash present. This is because maltodextrin breaks down at high temperatures, leading to an increased evaporation, which ultimately results in a reduction of ash content. **Caliskan and Dirim (2016)** reported that the addition of maltodextrin to sumac powder reduced the ash content.

Furthermore, the protein levels were examined, revealing that the protein levels in treatment A were 3.87% and in treatment B were 0.85%, indicating a significant decrease. **Tarigan *et al*. (2023)** reported that *U. reticulata* has a high protein content of 10.68% (wt). The reduction in protein content is affected by the duration and temperature of the extracting process and drying of *U. reticulata* flavoring powder. It can also be seen in Table (1) that treatment A had a higher protein content than treatment B. The addition of maltodextrin to treatment B contributed to the decrease in protein content. This pertains to the quantity of bonds formed between maltodextrin and *U. reticulata* extract. The introduction of maltodextrin leads to the thickening of *U. reticulata* extract and its exposure to higher temperatures for longer durations. Consequently, this influences the stability of the bonds between maltodextrin and *U. reticulata* extract, which are susceptible to heat. The protein content correlates with the nitrogen chain in the bond between maltodextrin and *U. reticulata* extract, which causes the nitrogen content to decrease with the addition of maltodextrin. In addition, fat content was also studied. It was observed in this study that both treatments A and B had the same fat content. The addition of maltodextrin did not affect fat content. The fat content of *U. reticulata* was very low at 0.33%. The extraction and heating processes caused a decrease in fat content by 0.02%. Unlike the water, ash, and protein contents, the study found that treatment B had a significantly higher carbohydrate content (82.83%) compared to treatment A (1.26%). The high carbohydrate content in treatment B was influenced by maltodextrin addition. Maltodextrin is the primary constituent of carbohydrates, and its addition results in elevated carbohydrate levels in the *U. reticulata* natural flavoring powder. The findings of this study align with those of **Agustina *et al*. (2019)**, who demonstrated that the addition of maltodextrin in phycocyanin powder can increase the carbohydrate content.

Water activity (aW) is a crucial characteristic that affects the safety and shelflife of food products. Water activity is related to the availability of water in the food matrix; higher water activity affects the growth of microorganisms, chemical, and biochemical reactions in the food product (**Gichau *et al*., 2020**). Therefore, it is necessary to determine the water activity of food products. A good water activity standard is defined as being below 0.7. At a water activity level of 6, microbiological activity and enzymatic processes are suppressed, ensuring that the product is considered safe and has a long shelf life. As shown in Table (1), the water activity of both *U. reticulata* flavoring powder products was very low. The *U. reticulata* flavoring powder product obtained had an Aw value below 7. **Mayasari *et al*. (2018)** also reported similar research findings, showing that instant seasoning of san-sakng leaves (*Albertisia papuana* Becc.) had a low Aw value of 0.51. In addition, **Caliskan and Dirim (2016)** postulated that sumac extract powders have a very low water activity of 0.20-0.40. This low water activity is considered stable against browning reactions, fat oxidation, microbial growth, and hydrolytic and enzymatic reactions **(Caliskan & Dirim, 2016)**. Therefore, *U. reticulata* flavoring products have a long shelf life. In addition, the study also examined the yield value, revealing that treatment B had the highest yield value of 10%, while treatment A had a yield value of 6%. The disparity in the yield value can be attributed to the addition of maltodextrin in treatment B, leading to an elevated yield value.

According to **Jönsson *et al*. (2023)**, amino acids are derivatives of proteins that contribute to sweet (serine, glycine, alanine, proline), bittersweet (lysine, threonine, valine), bitter (arginine, histidine, isoleucine, leucine, methionine, tyrosine, phenylalanine), umami (aspartic acid and glutamic acid), and sulfur (cysteine) flavors. Aspartic acid and glutamic acid are responsible for umami flavor **(Shangguan *et al*., 2024)**. The study's findings reveal that treatment A exhibited the highest levels of aspartic acid and glutamic acid, surpassing those observed in treatment B. The presence of maltodextrin contributed to this difference, resulting in a reduction in aspartic acid and glutamic acid. Generally, seaweeds contain glutamic and aspartic acids **(Raja*et al*., 2024)**. Consistent with the findings of **Meiyasa *et al*. (2020)**, seaweed sourced from Moudolung waters contains elevated levels of glutamic acid and aspartic acid, surpassing the concentrations of other amino acids. *U. reticulata* contains 6300ppm of glutamic acid and 5200ppm of aspartic acid, while *Turbinaria ornata* contains 8400ppm of glutamic acid and 5800ppm of aspartic acid. **Manam and Subbaiah (2020)** also reported that *Colpiomenia sinuosa* and *Halymenia porphyroides* seaweeds contain high levels of glutamic and aspartic acids. Furthermore, **Norkama *et al*. (2021)** have documented that *Kappaphycus alvarezii* contains significant amounts of aspartic acid and glutamic acid, even after undergoing fermentation with microbes, resulting in a remarkably elevated value. Seaweed is currently being investigated both as a main ingredient and as a food additive in food products. **Raja *et al.* (2022)** utilized seaweed as a novel food option, including snacks, noodles, health beverages, pastries, crackers, confections, salads, and spices manufactured in the European Union, United States, and South Asian countries. Seaweed is used in the food sector due to its umami flavor. The unique umami flavor of seaweed is attributed to the presence of organic acids, amino acid salts, and peptides **(Raja *et al*., 2022; Young *et al.*, 2022; Kumar *et al.*, 2023)**. This distinct flavor has led to a global increase in the consumption of seaweed-based food products **(Milinovic *et al*., 2021; Rogel-Castillo *et al*., 2023; Jayakody & Vanniarachchy, 2024)**.

The minerals investigated in this study were potassium, sodium, chloride, magnesium, manganese, iron, and zinc. The presence of minerals significantly affects the body's intake of nutrients. The results indicated that potassium, sodium, chloride, and magnesium exhibited greater values compared to manganese, iron, and zinc, respectively. Seaweeds are known for their capacity to absorb and retain inorganic compounds in water, resulting in a high mineral content **(Mohammed *et al*., 2021; Bekah *et al*., 2023; Dassa & Meiyasa, 2023; Ghaliaoui *et al*., 2023; Rondevaldova *et al*., 2023; Skrzypczyk *et al*., 2023)**. **Mohammed *et al*. (2021)** also reported that sodium and potassium are among the most abundant minerals found in seaweeds. Sodium is an important mineral in the body because it maintains hormonal balance, which regulates the stress levels and reproductive hormones **(Ali, 2023; Irabor *et al*., 2023)**. However, excessive sodium consumption (>2 g/day) causes adverse health effects, such as weight gain, obesity, hypertension, and other cardiovascular diseases **(Ali, 2023; Flexner *et al*., 2023)**. The recommended daily salt intake, according to the WHO, is less than 2 grams per day. The salt amount present in *U. reticulata* flavoring powder remains below the acceptable range for its usage as a flavoring agent in processed food. In addition, the study also examined potassium levels, which were found to be elevated. Seaweed has a higher potassium content compared to the minerals found in fruits and vegetables **(Mohammed *et al*., 2021; Akhter *et al*., 2024)**. It has also been reported that consuming potassium can protect against hypertension and other cardiovascular diseases **(Burnier, 2019; Xu *et al*., 2024)**. The WHO advises a daily potassium intake of no more than 3510mg, with a sodium-to-potassium ratio of 1.0 or below.

Wijendra and Bell (2019) state that a sodium-to-potassium ratio of 1.0 is crucial for regulating blood pressure and preventing excessive release of potassium-containing fluids in patients with hypertension. The ratio of sodium and potassium in the *U. reticulata* flavoring powder produced in this study is almost close to the ratio of 1.0, namely 1.38 (treatment A) and 1.42 (treatment B). The results of this study are lower than those reported by **Kurniawan*et al*. (2019)**, who reported that the sodium-potassium ratio of seaweed salt (*U. lactuca*) was 2.0-4.0. Similarly, **Nurjanah *et al.* (2018)** reported that the sodium-potassium ratio of *U. lactuca* seaweed salt was 3.0-4.0. In addition, **Nurjanah *et al*. (2022)** determined that seaweed salt derived from *S. polycystum* had a lower sodium and potassium ratio of 0.24-0.39. The variation in sodium and potassium ratios in seaweed-based flavoring powders can be attributed to the distinct sodium and potassium content obtained from different species of seaweed, resulting in differing ratios of these elements. The sodium-to-potassium ratio of 1.0 contributes to the prevention of high blood pressure **(Mohammed *et al*., 2021)**. The results of a study by **Kim *et al*. (2009)** reported that seaweed-fortified salt can reduce blood pressure and improve mineral and fat metabolism in rats.

The chloride produced in this study was also quite high at 806.92ppm for treatment A and 79.34ppm for treatment B. The high chloride content in the results of this study was due to the relatively high value of chloride in fresh seaweed. **Soares *et al*. (2020)** found that *Saccorhiza polyschides* seaweed has a high chloride content of 17419.87ppm, thus contributing to the high chloride content in the resulting flavoring powder. **Ali *et al*. (2023)** also assessed that seaweed contains high chloride levels. Chloride plays an important role in the distribution of vital fluids in the body, helps the absorption of nutrients in the body, and helps maintain kidney function. Chloride is present in various compounds, including sodium chloride (table salt), sea salt, and seaweed salt **(Kurniawan *et al.*, 2019; Nurjanah *et al*., 2022; Ali, 2023)**.

Magnesium has also been reported to have a high value in *U. reticulata* flavoring products. Treatment A was at 692.95ppm, and treatment B was at 92.72ppm. The high Mg content in this flavoring product is due to the high levels of Mg present in seaweed. *U. reticulata* from Moudolung waters in East Sumba exhibits a greater magnesium concentration (299.94ppm) compared to other minerals **(Dassa & Meiyasa, 2023)**. This contributed to the high Mg content. The same finding was also reported by **Lozano-Muñoz and Díaz (2020)** denoting that *U. clathrata* contains high magnesium levels of 35,000ppm. Consumption of foods, particularly those derived from seaweed rich in magnesium, can reduce blood pressure **(Lozano-Muñoz & Díaz, 2020)**, prevent diabetes, osteoporosis, bronchial asthma, preeclampsia, migraine, and cardiovascular disease **(Alawi *et al*., 2018)**. The recommended daily magnesium requirement is 320-420mg per day **(Tarleton, 2018)**. Furthermore, manganese (0.31-1.27ppm), iron (0.52-2.21ppm), and zinc (0.01-0.04ppm) had the lowest levels in the *U. reticulata* flavoring powder products. Low levels of manganese, iron, and zinc are due to low levels of manganese, iron, and zinc minerals in fresh *U. reticulata*. **Lozano Muñoz and Díaz (2020)** found similar findings, reporting that *U. clathrata* contains manganese levels of 0.051mg/ g, zinc levels of 0.18mg/ g, and iron levels of 1.71mg/ g.

Sodium chloride (NaCl) is a significant marker for analysis, as it has a strong correlation with hypertension. High salt consumption can increase hypertension **(Rust & Ekmekcioglu, 2017)**. Based on the Indonesian National Standard (SNI), the maximum dietary salt content of NaCl was 60% **(BSN, 2016)**. Dietary salt itself is iodized salt, which is consumed either in liquid or solid form. The NaCl level of the *U. reticulata* flavoring powder in treatment A was 10.97%, whereas it was 1.13% in treatment B. These findings met the recommended dietary salt threshold of less than 60%. **Seulalae *et al*. (2023)** also documented comparable findings, revealing that *S. polycystum* and *U. lactuca* seaweed salts possess NaCl concentrations of 43.77 and 18.98%, respectively. Similarly, **Kurniawan *et al*. (2019)** and **Nurjanah *et al*. (2020)** also reported that *U. lactuca* salt has low NaCl contents of 10.39 and 23.90%, respectively. The *U. reticulata* flavoring powder, with its low NaCl level (<60%), is highly suitable for those with hypertension. **Nurjanah *et al*. (2020)** reported that consuming salt with reduced NaCl content can effectively treat hypertension without compromising sensory quality and flavor.

The heavy metals studied were mercury and lead. The objective of heavy metal analysis is to ensure that the products manufactured are devoid of any heavy metal impurities. The findings indicated that both treatment A and treatment B of *U. reticulata* flavoring powder exhibited no presence of heavy metal contaminants. This indicates that *U. reticulata* flavoring powder products are categorized as safe for consumption.

According to the SNI-3556-2016 standard, the acceptable level of heavy metals is a maximum of 10ppm for lead and a maximum of 0.1ppm for mercury. No heavy metal contamination was detected in *U. reticulata* flavoring powder because the samples obtained from Moudolung waters were in excellent condition in terms of the coastal environment and water quality. Due to the absence of community activities in the surrounding environment, water contamination is nonexistent. Therefore, the ecological viability of the Moudolung waterways is preserved. According to the study conducted by **Konda and Meiyasa (2023)**, the waters of Sumba are classified as safe, indicating the absence of any significant levels of heavy metal contamination in seaweed raw materials.

CONCLUSION

The flavoring powder product derived from *Ulva reticulata* in this study exhibited a NaCl content of less than 60% and a Na/K ratio close to 1.0. This indicates that *U. reticulata* flavoring powder can be considered a potential antihypertensive agent.

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